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Operating manual

PM 3210 25 MHz Dual-trace oscilloscope

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9499 440 07611

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IMPORTANT

In correspondence concerning this apparatus, please quote the type number and serial number as given on the type plate at the bottom of the apparatus.

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GENERAL INFORMATION

This section of the instruction manual deals with introductory material and basic information of interest to both operating and servicing personnel.
It includes specifications of physical and electrical data and a description of the operating principles of the instrument to block diagram level.
The three chapters found in this section are:

I. INTRODUCTION
II. TECHNICAL DATA
III. DESCRIPTION OF THE BLOCK DIAGRAM

Fig. 1. General view

I. Introduction

The PM 3210 is a dual-trace oscilloscope with a bandwidth of 25 MHz at a maximum sensitivity of 1 mV/cm. The built-in electronic switch provides a great number of operating modes: CHANNEL A, CHANNEL B, CHOPPED, ALTERNATE, ADDED and XY. The mode XY with the same high sensitivity for the X and Y channels, together with a bandwidth of 5 MHz and a phase difference of less than 2^{o} between the channels, makes this instrument very useful for colour-television measurements.

The mechanical construction of the instrument shows a building-brick system that ensures an extremely quick and efficient service.

II. Technical data

Y AXIS

Two identical amplifier channels A and B. The polarity of both channels can be inverted.

Bandwidth	DC: 0 Hz ... 25 MHz (–3 dB) AC: 2 Hz ... 25 MHz (–3 dB)
Rise time	14 ns
Deflection coefficients	14 calibrated ranges from 1 mV/cm to 20 V/cm in 1–2–5 sequence. A vernier provides uncalibrated, continuous control between the ranges.
Measuring accuracy	± 3 %
Overshoot (in position 50 mV/cm of the input attenuator)	less than 2 % for pulses with a rise time ⩾ 3 ns and a trace height of 6 cm
Input impedance	1 MΩ//15 pF
Input RC time with a.c. coupling	100 ms
Maximum input voltage	500 V (d.c. + a.c. peak)
Maximum deflection	for sine-wave signals with frequencies up to 10 MHz, the vertical deflection is undistorted for a total amplitude equivalent to 24 cm. With the aid of the shift controls, the peaks of such a signal can be displayed.
Signal delay	delay time for each channel: 150 ns visible delay : ⩾ 20 ns
D.C. drift at maximum sensitivity	1 cm/hour at a constant ambient temperature of 25 °C (77 °F)
Display modes	– channel A only – channels A and B chopped, the display time for each channel being 1 µs – channels A and B alternate – channels A and B algebraically added. Using the polarity inversion of both channels, the following displays are possible: A+B, A–B, B–A, –B–A. Common mode rejection factor: 100 (from 0 Hz to 1 MHz, after adjustment of GAIN ADJ.) Maximum signal per channel: 24x attenuator setting – X-Y operation. Channel B forms the horizontal channel Bandwidth: 0 Hz ... 5 MHz with a phase difference of 2° at maximum between the channels. Maximum deflection in X direction: 6 cm for sine-wave signals with frequencies up to 5 MHz. – channel B only
Y signal output	approximately 200 mV/cm. The output is protected against short-circuits

CALIBRATION

Calibration voltage	1 V ± 1 %, square wave
Frequency	approximately 2.5 kHz

TIME AXIS

Time coefficients	21 calibrated ranges from 100 ns/cm to 0.5 s/cm in 1–2–5 sequence. A vernier provides uncalibrated, continuous control between the ranges.
Measuring accuracy	± 3 %
Magnifier	5x (50 cm). Any 10 cm of the expanded sweep can be displayed. The maximum effective time coefficient is 20 ns/cm. The measuring accuracy with expanded sweep is ± 5 % (measured between 10 % and 90 % of the time-base sweep).
Time-base output	5 V, sawtooth voltage. The output is protected against short-circuits. Output resistance: 2 kΩ Load : With an $R_{load} \geqslant 5$ kΩ and a $C_{load} \leqslant 100$ pF, the deviation of the time coefficient is less than 10 %

TRIGGERING

Trigger system	the time-base generator operates in the triggered mode when an input signal is applied. An auto-circuit can be switched in to provide a time-base line in the absence of an input signal.
Trigger source	channel A, channel B or external source
Trigger slope	+ or –
Trigger coupling	in position LEVEL DC : 0 Hz ... 25 MHz HF : 10 kHz ... 25 MHz LF : 10 Hz ... 10 kHz in position AUTO DC : 10 Hz ... 25 MHz HF : 10 kHz ... 25 MHz LF : 10 Hz ... 10 kHz

Trigger sensitivity and bandwidth

	0 Hz–10 Hz		10 Hz–10 kHz		10 kHz-5 MHz		5 MHz–15 MHz		15 MHz–25 MHz	
	INT.	EXT.	INT.	EXT.	INT.	EXT.	INT.	EXT.	INT.	EXT.
LF	–	–	0.5 cm	0.5 V	–	–	–	–	–	–
HF	–	–	–	–	0.5 cm	0.5 V	1 cm	0.5 V	3 cm	1 V
DC	0.5 cm	0.5 V	0.5 cm	0.5 V	0.5 cm	0.5 V	1 cm	0.5 V	3 cm	1 V

Input impedance of the external trigger input	1 MΩ//40 pF
Maximum input voltage	500 V (d.c. + a.c. peak)
Level range (measured with 10 kHz signal and continuous attenuator in position CAL.)	– internal level : more than 16 cm – internal auto : approximately 3 cm – external level : more than 10 Vp-p – external auto : approximately 1.5 Vp-p

C.R.T.

Type	D14–120GH with medium-short persistence phosphor *)
Useful screen area	8 cm x 10 cm
Graticule	external, with cm-divisions
Total acceleration voltage	10 kV

*) Instruments fitted with a GM-tube with long persistence phosphor are available under type number PM 3210G.

Z-MODULATION

Internal	unblanking by time-base generator. In position CHOPPED the beam is suppressed during switching.
External	D.C. coupled
Required voltage	5 Vp-p (50 Vp-p at maximum)
Short-term overload	500 Vp-p at maximum
Input impedance	approximately 10 kΩ // 20 pF
Bandwidth	0 Hz ... 10 MHz

SUPPLY PART

Mains voltages	110 V, 125 V, 145 V, 200 V, 220 V, 245 V
Mains frequency	46–400 Hz
Power consumption	95 W
Influence of ± 10 % mains voltage fluctuations	nil

ENVIRONMENTAL CONDITIONS

The instrument can be used either in horizontal or vertical position.

Temperature range	Operating within specification	: 0 ... +45 °C
	Operating	: –10 ... +55 °C
	Storage	: –40 ... +70 °C

The instrument meets the VDE 0875 Störgrad K requirement.

OVERALL DIMENSIONS AND WEIGHT

Height	: 20 cm
Width	: 30 cm
Depth	: 47.5 cm
Weight	: 13 kg

Properties expressed in numerical values with tolerances stated are guaranteed by the factory. Numerical values without tolerances stated represent the properties of an average instrument and merely serve as a guide. All data apply in case of nominal mains voltage unless otherwise stated.

OPTIONAL ACCESSORIES

(The standard accessories supplied with the instrument have been listed in Chapter IV. INSTALLATION.)

– Passive probe with 1.15 m cable	PM 9326
– Passive probe with 2 m cable	PM 9327
– Passive h.f. probe	PM 9350
– Polaroid oscilloscope camera	PM 9380
– Adapter for camera	PM 9378
– Supplementary lens	PM 9373
– Rack-mount kit	PM 9361
- Trolley	PM 9395

III. Description of the block diagram

Y-AXIS

An input signal applied to socket Y_A or Y_B is fed to unit 1 or unit 2. These units are identical and contain the following circuits: an input step-attenuator, a protection circuit, a pre-amplifier and a drift-compensation circuit, the continuous attenuator and the gain pre-set control.
The protection circuit prevents damage to the input field-effecttransistors by too high an input voltage.
The drift-reduction circuit reduces the drift inherent in the high sensitivity of the amplifier.
Via the delay line the signal is fed to the intermediate amplifier on printed-wiring card 4.

Printed-wiring card 4 comprises four main parts:
1. an intermediate amplifier receiving the signal from the pre-amplifier of channel A.
2. an identical amplifier for channel B. These two amplifiers are equipped with shift and polarity controls.
3. the diode switch, which is controlled by the switch-driver circuit.
4. the Y output amplifier that feeds the signal to the vertical-deflection plates.

TRIGGERING

The triggering signal from the pre-amplifier of channel A or B, or from an external source can start the time-base generator (unit 3).

TIME BASE

The time-base unit is provided with an optional auto-circuit that makes the time-base generator free-running when there is no triggering signal.
The time-base unit supplies the following output voltages:
1. a sawtooth voltage. Via the printed-wiring board this sawtooth voltage is fed to the X-amplifier unit 7 and to a socket on the rear panel of the instrument.
2. a gate pulse which is fed to combination unit 8 via the printed-wiring board. This gate pulse controls the unblanking of the c.r.t. during the sweep.
3. an alternate pulse. This pulse controls the switch driver unit 5, which in its turn controls the diode switches.

X-AXIS

The X amplifier consists of three parts:
1. the time-base amplifier. This amplifier feeds the sawtooth voltage from time-base unit 3 symmetrical and amplified to:
2. the diode switch which, as dictated by switch driver unit 5, connects the time-base signal or the signal from channel B to:
3. the X-output amplifier which feeds the signal to the X-deflection plates of the c.r.t.

DIODE SWITCH

The diode switch is part of the horizontal as well as of the vertical path and can, together with the switch driver, accomplish the following situations.
1. Channel A is connected to the Y output amplifier and the sawtooth voltage from unit 3 is fed to the X-amplifier.
2. Channels A and B are in turns connected to the Y output amplifier for approx. 1000 ns (position CHOPPED). The sawtooth voltage from unit 3 is connected to the X-amplifier.
3. Channels A and B are alternately connected to the Y output amplifier at every fly-back of the time-base sweep (position ALTERNATE).
   The sawtooth voltage from unit 3 is fed to the X-amplifier.
4. Channel B is connected to the X output amplifier and channel A to the Y output amplifier (position X-Y).
   In this position the bandwidth is limited in the Y output amplifier. The bandwidths of the two channels (A vertical and B horizontal) are now the same (5 MHz at a phase difference $\leqslant 2^{o}$).
5. Channel B is connected to the Y output amplifier, the sawtooth voltage from unit 3 is fed to the X-amplifier.

SWITCH DRIVER

The switch driver unit 5 consists of the following parts.
1. a push-button switch, which enables the switching in of the positions described above.
2. a blocking oscillator which oscillates at a frequency of about 2 MHz, in position CHOPPED.
   In position ALTERNATE the blocking oscillator is triggered by the alternate pulse. Triggering is such that the oscillator supplies a pulse at every fly-back of the

time-base sweep.
The output pulse of this oscillator controls the driver generator.
In positions A, B, ADDED and X-Y the blocking oscillator is inoperative; the driver generator is then controlled by the push-button switch.

3. The driver generator, which supplies voltages required to obtain the different positions of the diode switch.

THE COMBINATION UNIT

This unit comprises the following circuits.

1. The unblanking circuit which unblanks the c.r.t. during the sweep of the time-base.
2. The blanking circuit which suppresses the beam during the switching between channels A and B.
3. The external Z-modulation circuit.
4. The calibration-voltage generator.
   This generator provides a square-wave voltage of 1 V ±1 % at a frequency of about 2.5 kHz.
5. Graticule-illumination circuit, which provides a graticule illumination which is independent of mains-voltage variations.
6. Voltage stabilizer, which keeps the 23 V input voltage of the converter at a constant value during mains-voltage and load variations.
   The stabilizer provides together with unit 10 (mains-voltage transformer + rectifier) and the series regulator on the rear of the instrument, the supply voltage for the converter.
7. Connector unit 6. This unit consists of a square-wave converter with a frequency of about 18 kHz.
   The power pack provides all supply voltages for the instrument, viz. + and −23 V, + and −95 V, −1600 V and +8500 V.

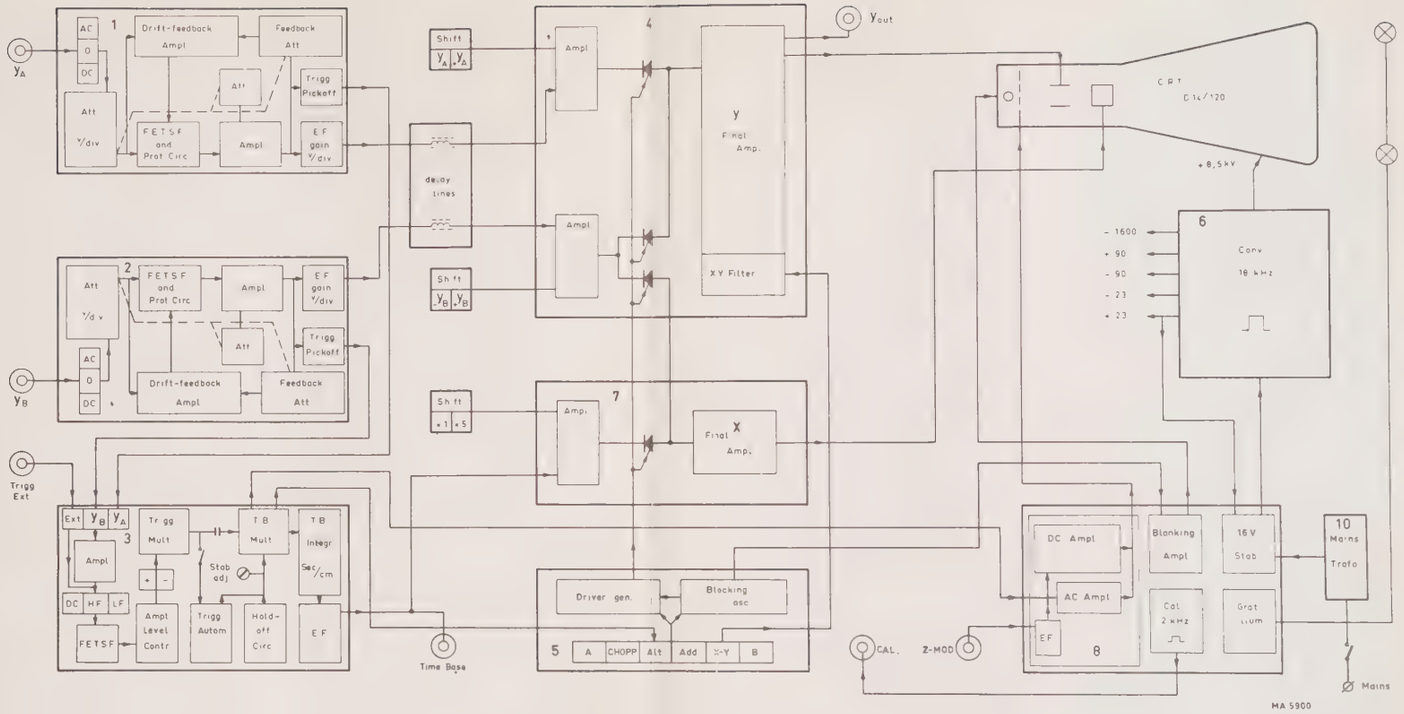

Fig. 2. Block diagram

DIRECTIONS FOR USE

This section of the instruction manual is essentially of interest to operating personnel. It deals with the information necessary for installing and operating the equipment correctly, outlines its capabilities, reviews basic measuring principles and suggests techniques for obtaining the best results in various applications.

The three chapters found in this section are:

IV. INSTALLATION
V. OPERATING INSTRUCTIONS
VI. APPLICATIONS
VII. BRIEF CHECKING PROCEDURE

IV. Installation

The PM 3210 oscilloscope is despatched complete with the following accessories which are stowed, for transit, in the packing spaces in front of and behind the instrument. These items are:

1. two BNC-4 mm adapters PM 9051
2. a green filter
3. an instruction manual

On receipt, remove these accessories and the instrument from the carton and examine them to ascertain whether any damage has been sustained in transit.
Remove the cover by means of the two screws with which the handle is attached and the two screws near the rear panel. Check that all printed-circuit cards are fully inserted and visually inspect the interior.
Replace the cover.

A. MAINS ADJUSTMENTS AND FUSES

Before switching on, the instrument should be adjusted to the local mains voltage by means of the voltage adapter inside the instrument.
Provision is made for selecting 110 V, 125 V, 145 V, 200 V, 220 V and 245 V. The voltage selected is displayed through an aperture at the right-hand side of the instrument. The mains-voltage adapter can be set after removal of the cover.
The fuse-holder on the rear panel normally carries a 1 A delayed-action mains fuse but if the instrument is to be connected to a mains voltage of less than 200 V, a 2 A fuse should be fitted.

A thermal cut-out is incorporated as an integral part of the mains transformer to prevent excessive over-heating in the case of a prolonged short circuit.

B. EARTHING

In the interests of safety, the instrument should be earthed via the earth terminal ⏚ on the front panel, the earth screw ⏚ on the rear panel, or via the mains flex if this has a plug with an earth connection.

NOTE: Double-earthing must be avoided as this may cause hum on the trace.

C. SWITCHING ON

The instrument is switched on by means of the POWER ON switch. The white pilot lamp illuminates to indicate this condition when the mains are connected and the POWER ON switch is in the "up" position.
The instrument can be used in horizontal, vertical or tilted position, but care should be taken that a free air circulation is not impeded. For temperature conditions refer to chapter II.

WARNING:
This instrument generates high voltages and should not be operated with the covers removed. The mains plug should be removed before attempting any maintenance work, and any relevant high voltage points discharged.
Never switch on the instrument when any printed-circuit card has been removed and never remove any printed-circuit card when the instrument is switched on.

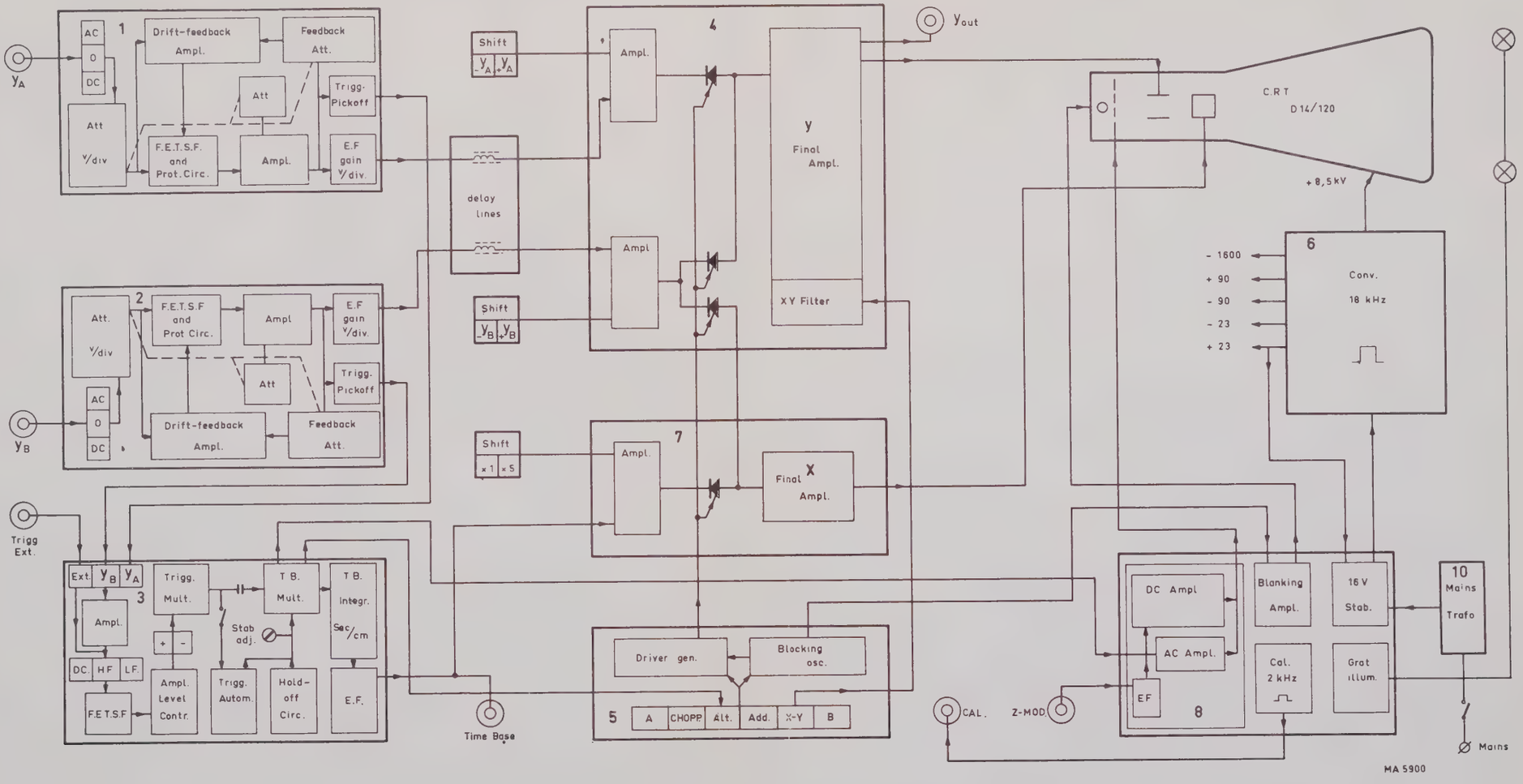

Fig. 2. Block diagram

ADDED	: vertical deflection is achieved by the sum signal of channels A and B.
XY	: horizontal deflection is achieved by a signal applied to the B channel and vertical deflection by a signal connected to the A channel.
B	: vertical deflection is achieved by the signal connected to the channel B input.

Channel A/B

AC–0–DC (SK9/SK11)	signal coupling, three position switch: AC : via a coupling capacitor. 0 : interruption of connection between input socket and input circuit, the latter being earthed. DC : direct coupling.
AMPL. (SK12/SK13)	control of the vertical deflection coefficients, 14-way switch.
CAL–AMPL. (R8/R13)	continuously variable control of the vertical deflection coefficients. In the CAL. position the deflection coefficient is calibrated.
GAIN ADJ. (R9/R12) (screw-driver operated)	continuously variable control of the gain of the vertical channels.
DC BAL (R10/R11) (screw-driver operated)	continuously variable control of the direct voltage balance of the vertical amplifiers.
1 MΩ/15 pF (BU3/BU5)	input BNC socket for the vertical deflection signals.
SHIFT (R14/R15)	continuously variable control giving vertical positioning of the display.
PULL FOR –A/–B (SK14/SK15)	push-button control for inversion of the signal polarity.

Cathode Ray Tube Controls

INTENS. (R2)	variable control of trace brightness.
FOCUS (R3)	variable control of electron beam focusing.
ILLUM. (R5)	variable control of graticule illumination.

Miscellaneous Controls

POWER ON (SK1)	toggle switch for the mains supply to the oscilloscope.
CAL. 1 V (BU2)	output BNC socket for 1 V square-wave voltage for calibration purposes.
⏚ (BU4)	earth socket.

Sockets on the rear panel (Fig. 4)

TB OUT (BU6)	sawtooth output BNC socket.
Y OUT (BU7)	Y-amplifier output BNC socket.
Z-MOD (BU8)	input BNC socket for intensity-modulation voltages.

B. PRELIMINARY SETTINGS

We recommend to allow a warming-up period of approximately 5 minutes before you start your measurements.

- Check that the mains voltage adapter indicates the local mains voltage. If necessary remove the cover and set the adapter to the relevant value and see that the right fuse has been inserted.
- Switch on the instrument.
- Set ILLUM R5 for a suitable graticule illumination.
- Set INTENS R2 and FOCUS R3 to their mid-positions.
- Pull LEVEL SK5 to position AUTO.
- Display two traces by means of SHIFT controls.

The oscilloscope is then ready for use.
For minor adjustments, such as d.c. balance or gain, refer to chapter VII. BRIEF CHECKING PROCEDURE.

C. THE INPUTS A AND B AND THEIR POSSIBILITIES

The PM 3210 has been provided with two identical inputs and pre-amplifiers which can be used in various combinations, either for YT measurements in combination with the time-base generator, or for XY measurements up to frequencies of 5 MHz.

1. YT Measurements

a. Displaying one signal

To display one phenomenon either of the two vertical inputs can be selected by operating push-button A or B of switch SK10.
The polarity of the display can be inverted by pulling the SHIFT knob of the relevant channel.
One channel display ensures the highest intensity, and writing-speed for single transients and other signals with low duty-cycles.

b. Displaying two signals

When push-button CHOPPED or ALTERN. of switch SK10 is operated, two different signals can be displayed simultaneously. The Y deflection coefficient and the polarity can be selected for each channel individually.
When push-button ALTERN. of SK10 is depressed, the display is switched over from one channel to the other at the fly-back of the time-base signal.
Although the ALTERN. mode can be used at all sweep times of the time-base generator, the CHOPPED mode will give a better display quality for long sweep-times, because during these long sweep-times the alternate display of the two connected signals is clearly visible to the eye.
In the CHOPPED mode, the display is switched over from one channel to the other with a fixed frequency. With short sweep-times the display quality will be better in the ALTERN. mode.

If push-button ADDED of switch SK10 is operated, the voltages of both vertical channels are added. Depending on the positions of the polarity switches, either the sum or the difference of the input signals is displayed.
The ADDED mode also enables differential measurements. With these measurements advantage is taken from the common mode rejection in the ADDED mode. When the polarity switches are set to opposite positions, the common mode parts of the signals on sockets Y_A and Y_B will undergo a very slight amplification only, with respect to the differential mode parts.

2. XY Measurements

If push-button XY of switch SK10 is operated, the time-base generator is switched off. The signal of the B channel is horizontally displayed. The B channel knobs then control the horizontal deflection.
In this mode, calibrated XY measurements can be effected at frequencies up to 5 MHz. For this frequency range the phase difference between both channels is less than 2^{o}.

3. Influence of the AC–0–DC switch

The signals to be studied are fed to the input sockets Y_A, Y_B, or both. Depending on the composition of this signal, switch AC–O–DC should be set to position AC or DC. In position DC, the input is directly coupled to the Y amplifier. Because the Y amplifier is a d.c. coupled amplifier the complete bandwidth of the instrument is available. This means that input voltages are fed entirely to the deflection plates, which implies that d.c. components result in trace shifts on the screen.
This may cause difficulties when signals superimposed on high direct voltages have to be displayed. In order to make the a.c. signal visible in those cases, a greater attenuation will be necessary with the result that the a.c. signal will also be strongly attenuated. In this case the AC–0–DC switch can be set to position AC. Then a blocking capacitor is connected between the input socket and the Y amplifier and, therefore, not only the direct voltages but also the lower frequencies are suppressed or attenuated. When square-wave signals of low frequency are displayed, this will result in some pulse droop.
In position 0 of the AC–0–DC switch, it is possible to quickly determine the zero volt d.c. level. In this position the connection between the input socket and the amplifier is interrupted and the amplifier input earthed.

D. TRIGGERING

1. General

To display a signal, the horizontal deflection must always be started at ONE fixed point of the signal, in order to obtain a stationary trace. The time-base generator is, therefore, started by narrow trigger pulses formed in the trigger unit, controlled by a signal originating from the vertical input signal or an external source.

2. Trigger coupling

The LF-HF-DC switch determines the method of coupling the signal into the trigger circuit. LF coupling blocks undesired d.c. levels and h.f. interference but responds to l.f. triggering signals.
HF coupling blocks d.c. and l.f. signals, e.g. hum, but respond to h.f. triggering signals.
DC coupling makes the full signal bandwidth available for triggering.

3. Automatic triggering

Automatic triggering, when the LEVEL knob is pulled out, is most often used on account of its simple operation. In this position it is possible to display a large number of wave forms having different amplitude and shape, without it being necessary to operate any of the trigger controls. If no triggering signal is present, a time-base line remains visible on the screen. This is useful for reference purposes. In this trigger mode, the level can be adjusted over approximately 3 cm of the trace.

4. Trigger level

In case of a complicated signal in which a number of non-identical voltage shapes occur periodically, the time axis should always be started with the same voltage shape, so as to obtain a stationnary trace. This is possible when one of the details has a deviating amplitude. By means of knob LEVEL, the trigger level can then be adjusted so that only this larger voltage variation passes this level. The LEVEL setting is also useful for the study of a leading edge. Then the trigger level can be set in such way that the time-base is already started at the beginning of this leading edge, owing to the delay line.

5. External triggering

External triggering is applied for signals having a strongly varying amplitude, if a signal having a fixed amplitude and equal frequency is available. This obviates the necessity of readjusting the level setting at every variation of the input signal.

E. TIME-BASE MAGNIFIER

The magnifier is operated by a push-pull switch. When this switch is in position x5, the time-base is increased 5 times. In position x5 of the magnifier, the sweep time of the sawtooth is determined by dividing the indicated TIME/cm value by 5.

F. Z-MODULATION

In order to bring extra information in the c.r.t. display without changing the wave form, the intensity of the trace can be varied by an externally applied voltage. The external signal must, therefore, be fed to the socket Z-MOD on the rear side of the instrument. The voltage required for visible intensity modulation depends on the position of the INTENS control. With an average brightness of the trace, a 5 Vp-p voltage is amply sufficient for obtaining a good visible Z-modulation.

VI. Applications

In the following we describe the procedure and the technique for basic measurements with a PM 3210 oscilloscope.

A. VOLTAGE MEASUREMENTS

Display the waveform as large as possible in order to obtain maximum accuracy. For all voltage measurements, the AMPL. potentiometer must be in the CAL position, otherwise the deflection co-efficients are not calibrated. When using a 10:1 attenuator probe, observe that the displayed amplitude must be multiplied by a factor 10. Ensure that the probe is adjusted for good step response, and, in the interests of accuracy, that the GAIN preset of the oscilloscope is checked.

A1. Peak-to-peak voltage measurements

To measure the peak-to-peak value of the a.c. component of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/cm switch to display a few cycles of the waveform as illustrated in Fig. 5.
2. Adjust the Y POSITION control so that the lower peaks of the waveform coincide with the nearest horizontal graticule line.
3. Adjust the X POSITION control so that one of the upper peaks of the signal coincides with the central vertical graticule line.
4. Measure the vertical distance between the peaks to the signal.
5. Multiply this measured distance by the voltage setting of the Y AMPL switch and by the attenuation factor of the probe, if any.

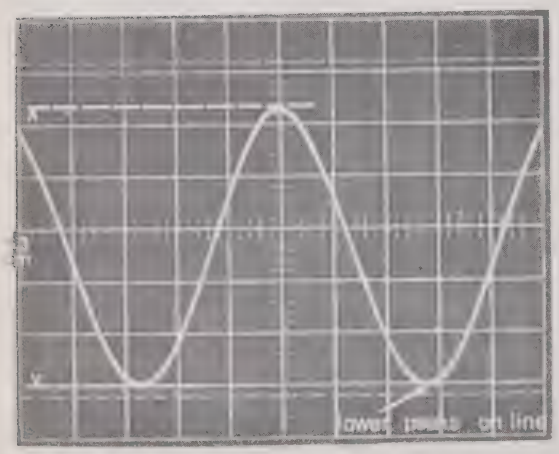

Fig. 5. Peak-to-peak voltage measurements

Example:
Assume that the AMPL switch is set to 2 mV/cm and a 10:1 attenuator probe is used. The measured vertical distance is 5.3 cm.

Using the formula:

$$\text{Volts}_{p\text{-}p} = \left(\frac{\text{vertical}}{\text{distance}}\right) \times \left(\frac{\text{AMPL}}{\text{setting}}\right) \times \left(\frac{\text{probe}}{\text{attenuation}}\right)$$

$$= 5.3 \times 2.10^{-3} \times 10$$

$$= 106.10^{\ 3} = 106 \text{ mV}$$

If the waveform is purely sinusoidal, the r.m.s. voltage is:

$$V_{r.m.s.} = \frac{V_{p\text{-}p}}{2\sqrt{2}} = \frac{106.10^{-3}}{2\sqrt{2}} = 38.2 \text{ mV}$$

A2. Instantaneous voltage measurements

To measure the instantaneous value of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the Y input switch to 0 and adjust the Y POSITION control so, that the zero reference line coincides with the nearest horizontal graticule line.

   NOTE: The Y POSITION control must not be moved after this reference line has been established.
2. Set the Y input switch to DC.
3. If desired, rotate the X POSITION control so that the point to be measured lies on the vertical centre line.
4. Measure the vertical distance between this point and the zero-reference line; if the point lies above the reference line, the voltage is positive; if the point lies below the line, the voltage is negative. (Make sure that the INVERT switches are in NORMAL position.)
5. Multiply the measured distance by the voltage setting of the Y AMPL switch and the attenuation factor of the probe, if any.

Example:
Assume that the Y AMPL switch is set to .1 V/cm and that a 10:1 attenuator probe is used. The measured vertical distance is 5 cm (Fig. 6).

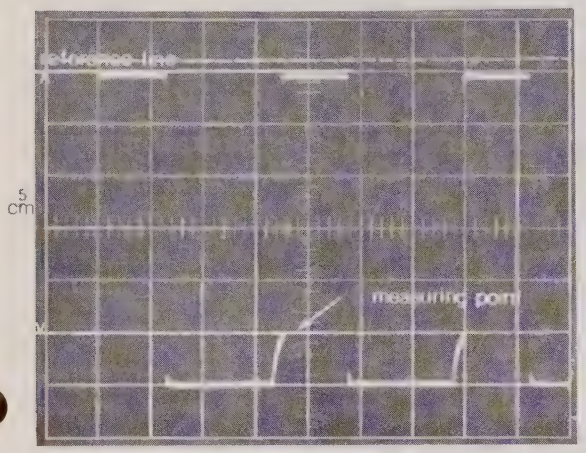

Fig. 6. Instantaneous voltage measurements

Using the formula:

$$\text{Instantaneous voltage} = (\text{vertical distance}) \times (\text{Y AMPL setting}) \times (\text{probe attenuation})$$

$$= 5 \times 10^{-1} \times 10$$

$$= 5 \text{ V, of negative polarity}$$

NOTE: To measure a voltage level with respect to another voltage rather than to earth, apply the reference voltage to the input socket. Adjust the Y POSITION control, so that the trace coincides with a horizontal graticule line, which can now be used as the reference line. This replaces the zero-reference procedure described in step 1.

B. TIME AND FREQUENCY MEASUREMENTS

For all time and frequency measurements, the TIME/cm potentiometer must be in the CAL position, otherwise the sweep speeds are not calibrated.

B1. Time measurements

To measure the time interval between two points of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible.
Then proceed as follows:

1. Set the TIME/cm switch so that the horizontal distance between the time-measuring points is as large as possible.
2. Rotate the X POSITION control so that one of the measuring points coincides with the nearest vertical graticule line.
3. Rotate the Y POSITION control to bring the other point to the horizontal centre line.
4. Measure the horizontal distance between the two time-measuring points.
5. Multiply the measured distance by the TIME/cm setting (if magnification is used, divide this product by 5).

Example:
Assume that the TIME/cm setting is .5 μs and the magnifier is on. The measured distance is 8.2 cm (Fig.7).

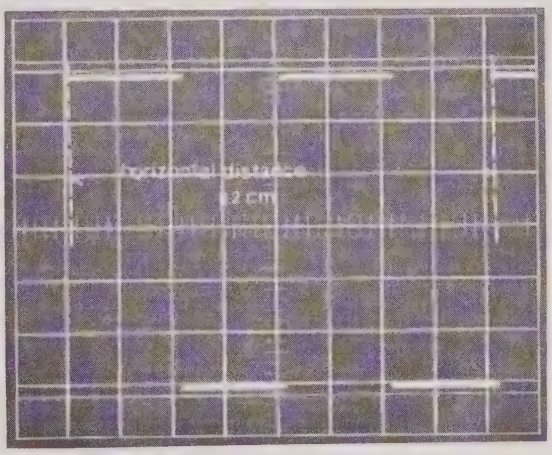

Fig. 7. Time measurements

Using the formula:

$$\text{Time interval} = \frac{\text{horizontal distance} \times \text{TIME/cm setting}}{\text{magnification}}$$

$$= \frac{8{,}2 \times 5.10^{-7}}{5}$$

$$= 0.82 \ \mu\text{s}$$

After measuring the time duration of one cycle in the way described above, the frequency can be easily calculated:

$$\text{frequency} = \frac{1}{\text{time-duration of one cycle}}$$

B2. Rise-time measurements

Rise-time is defined as the time required by the leading edge of a signal to rise from 10 % to 90 % of the amplitude.
When the oscilloscope rise-time is comparable with the signal under test, the actual rise-time should be calculated as follows:

$$\text{actual } t_r = \sqrt{(\text{measured } t_r)^2 - (\text{oscilloscope } t_r)^2}$$

This calculation is not necessary when the signal rise-time is longer than 50 ns (the error is then 5 % and decreases rapidly when the rise-time becomes longer).
To measure the rise-time of a signal, connect the signal to one of the Y input sockets and adjust Y controls to display as large a trace as possible.
Then proceed as follows:

1. Set the TIME/cm switch to display the total voltage step on the screen.
2. Adjust the Y amplitude so that the vertical deflection is exactly 8 cm.
   The 10 and 90 % points now coincide with the dotted lines of the graticule.
3. Adjust the X POSITION control so that the 10 % coincides with the nearest vertical graticule line; this line is now the time reference line, and no further adjustment of the X POSITION control should be made.
4. Measure the horizontal distance between the time-reference line (coincident with the 10 % point) and the point of intersection of the signal and the horizontal 90 % line.
5. The rise-time is given by the product of the horizontal distance in centimetres and the TIME/cm setting. If magnification is used, this product must be divided by 5.

Example (Fig. 8):
Assume that the TIME/cm setting is 200 ns and magnification is used. The oscilloscope rise-time is 14 ns.
The measured distance is 0.6 cm.

$$\text{Measured rise-time} = \frac{\text{TIME/cm setting x Horizontal distance}}{\text{Magnification}}$$

$$= \frac{2.10^{-7} \times 6.10^{-1}}{5} = 24 \text{ ns}$$

Substituting in the formula:

$$\text{actual rise-time} = \sqrt{(\text{measured rise-time}^2 - \text{oscilloscope rise-time}^2)}$$

$$= \sqrt{576 - 196} = \sqrt{380} = 19.5 \text{ ns}$$

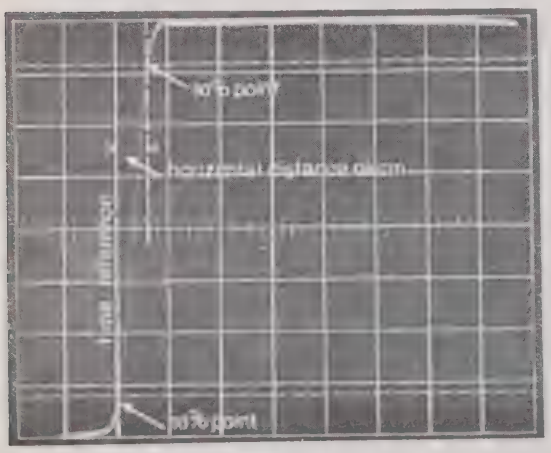

Fig. 8. Rise time measurements

C. PHASE MEASUREMENTS

To measure the phase difference between two sinusoidal signals of the same frequency, use the following method. Connect one signal to one of the Y input sockets and the other signal to the other Y input socket, using probes or coaxial cables **with equal time delays.** Display the traces using the AUTO mode of the time-base with the Y display-mode switch at CHOPPED (suitable for low frequencies) or ALTERN. (suitable for high frequencies). If the signals are of opposite polarity then pull one of the Y position controls to invert the lagging signal. Note that the total phase difference must be subtracted from 180° in this event. With a stable display of maximum amplitude, adjust the Y POSITION controls for symmetry about the horizontal centre-line.
When you have set up the display, proceed as follows:

1. Set the TIME/cm switch and potentiometer so that one cycle of the first signal occupies exactly 8 cm horizontally; i.e. each cm represents 360°/8 = 45°.
2. Measure the horizontal distance between the two corresponding points on the waveforms, and multiply this by 45° to obtain the phase difference.
   If one of the Y POSITION controls is pulled, subtract the result from 180°.

   NOTE: For small phase difference (less than 45°) use the x5 MAGN. push-button and divide the result by 5. The phase scale is now 9°/cm, therefore, the measured distance in centimetres should be multiplied by 9 to obtain the desired phase difference measurement.

D. X-Y MEASUREMENTS

The X-Y measuring method can be used for making phase measurements, frequency measurements, hysteresis measurements or for using the oscilloscope as a vector scope.

D1. Phase measurements

To measure the phase difference between two sinusoidal signals of the same frequency, use the following method: Connect one signal to one of the Y input sockets and the other signal to the other Y input socket, using probes or coaxial cables **with equal time delays.** Set the Y display-mode switch to X-Y and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. centre the display;
2. measure the distances **a** and **b** (see Fig. 9);
3. the sine of the phase angle is given by a/b. The phase angle can now be obtained from a trigonometric table.
   When a phase graticule is used, the phase difference can be read at once.

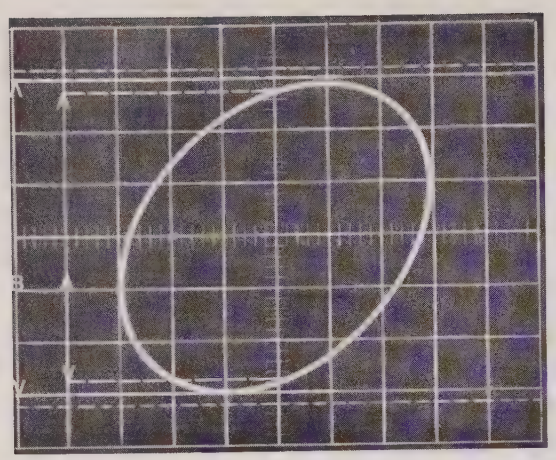

Fig. 9. Phase measurements, X Y method

D2. Frequency measurement

To measure frequencies, a signal with a known, adjustable frequency must be connected to input socket Y_B. The signal with the frequency to be measured must be applied to socket Y_A. Set the Y display-mode switch to X-Y and proceed as follows:

1. adjust the known frequency to obtain a stable display;
2. imagine a horizontal and vertical tangent to the obtained Lissajous figure;
3. count the points of contact n_x of the trace and the vertical tangent and the points of contact n_y of the trace and the horizontal tangent. If the Lissajous figure is not closed, the point of contact of the tangent with the open figure must be taken into account as half a point of contact.

Example:
Assume that $n_x = 4$, $n_y = 3$ and that the known frequency is 500 Hz (see Fig. 10).

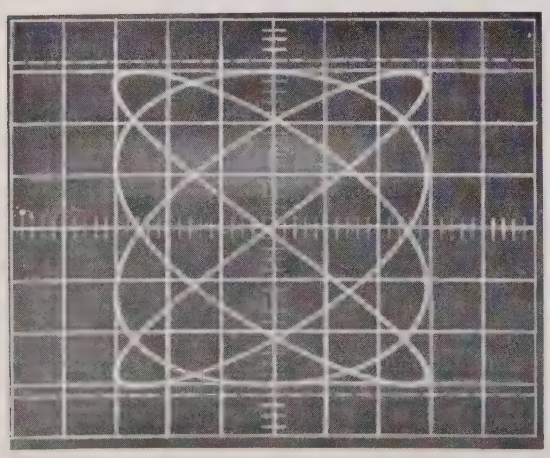

Fig. 10. Frequency measurements

Using the formula:

$$\text{unknown frequency} = \frac{n_y}{n_x} \text{ (known frequency)}$$

$$= 3/4 \times 500$$

$$= 375 \text{ Hz}$$

E. Y OUTPUT SIGNAL

Many advantages accrue from the fact that in this oscilloscope the internal triggering signal can be derived from either channel and is taken off before the electronic switch. The main advantages are:

- the trigger signal is merely a part of the input signal and is, therefore, devoid of interfering components such as are present in the chopped mode and may result in display instability;
- in the alternate mode, the possibility of time relationship errors between the displayed waveforms is avoided since the trigger signal is not a combination of two or more signals;
- the triggering is unaffected by the continuous AMPL. controls and the SHIFT/polarity controls of the Y amplifiers;
- a simple method is provided for triggering from either channel without the necessity of changing input connections or applying one of the signals to the external trigger input.

In this way misleading displays are prevented and a stable display is obtained very easily.
Sometimes, however, it may be necessary to display two signals with unrelated frequencies. External triggering with the Y signal of socket Y OUT, will then provide a stable display, when the instrument is operated in the ALTERN. mode.

Example:
Assume that you want to adjust a frequency to be a certain ratio of an accurately known frequency. Suppose that the known frequency is exactly 2 MHz and that the other frequency has to be adjusted to 5 MHz.

- Set the time base to display about 3 complete cycles of the 2 MHz signal.
- Set the display switch to position ALTERN.
  The input signals will be present at the Y output socket alternately for a complete sweep time.
- Connect the Y output socket to socket TRIGG (BU1).
  The d.c. level of each signal can be varied by means of the relevant SHIFT control.

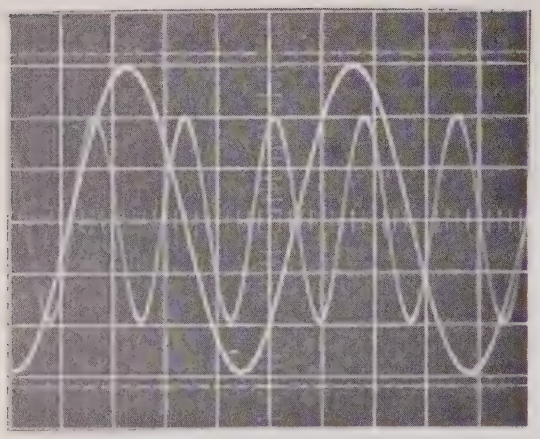

Fig. 11. Using the Y output signal

– Set coupling selector LF-HF-DC (SK2) to DC or HF to obtain stable triggering.
– Adjust LEVEL (R1) so that the sweep starts for both signals on the horizontal centre line of the graticule.

The frequency can now be adjusted to the desired value by making the end of the fifth cycle coincide with the end of the second cycle of the known frequency, as shown in Fig. 11.
This method is extremely accurate since measurements are independent of time-base inaccuracies.

VII. Brief checking procedure

This check should be performed with a nominal mains voltage.

Preliminary settings of the controls

- AC–0–DC (SK9/SK11) to position 0.
- Display switch SK10 to position CHOPPED.
- TIME/cm (SK6) to position 1 ms.
- Pull LEVEL (SK5) to position AUTO.
- Set SHIFT (R13/R14) and INTENS (R2) for two time-base lines.
- Set AMPL. (R8/R9) and TIME/cm (R13) to position CAL.
- Set AMPL. (SK12/SK13) to position 50 mV.

Unless otherwise stated, the controls should occupy these positions during all the following checking procedures.

Make sure that the instrument had a warming up time of half an hour before attempting any re-adjustment.

General check

- TIME/cm (SK6) to position 50 ms.
- Check the proper working of display switch SK10: Y_A, CHOPPED, ALTERNATE, ADDED, X–Y, Y_B.
- AC–0–DC (SK9) to position 0.
- Apply a sine-wave signal of a low frequency to socket Y_A (BU3).
- Adjust AMPL. (SK12) for a trace height of 6 cm.
- Check astigmatism; if necessary re-adjust potentiometer R1044 (Fig. 12).
- Check that the trace runs in parallel to the horizontal centre line of the graticule; if necessary re-adjust the trace rotation potentiometer R1048 (Fig. 13); the trace must be in the centre of the graticule during this adjustment.

Y amplifier

Display-switch SK10 to position Y_A.

- Check that the trace does not move when switch AMPL. (SK12) is rotated between positions 50 mV/cm and 1 mV/cm; if necessary re-adjust DC BAL (R10).
- AMPL. (SK12) to position 1 mV/cm.
- Switch AC–0–DC (SK9) over from 0 to DC. The trace should not shift; if necessary re-adjust potentiometer R143 (Fig. 14).
- Check the deflection co-efficients of channel A; tolerance + or −3 %. If necessary re-adjust GAIN ADJ. (R9).

Display-switch SK10 to position Y_B.

- Check that the trace does not move when switch AMPL. (SK13) is rotated between positions 50 mV/cm and 1 mV/cm; if necessary re-adjust DC BAL (R10).
- AMPL. (SK13) to position 1 mV/cm.

Switch AC–0–DC (SK11) over from 0 to DC. The trace should not shift; if necessary re-adjust potentiometer R343 (Fig. 13).

- Check the deflection co-efficients of channel B; tolerance + or −3 %. If necessary re-adjust GAIN ADJ. (R12).
- Display-switch SK10 to position X Y.

Check the deflection co-efficients of channel B in X direction; if necessary re-adjust potentiometer R944 (Fig. 12).

Check the amplitude and phase equality between X and Y amplifier up to a frequency of 5 MHz.

The deviation of the amplitude equality should not exceed 2 %; if necessary correct with trimmer C906 (Fig. 12). The phase difference should not exceed 2°; if necessary correct with potentiometer R946 (Fig. 12).

Time-base generator

Check the triggering with a sine-wave signal at a frequency of 25 MHz and a trace height of 3 cm.

- Check the sweep time in position 1 ms/cm; tolerance + or −3 %. If necessary re-adjust potentiometer R833 (Fig. 12).

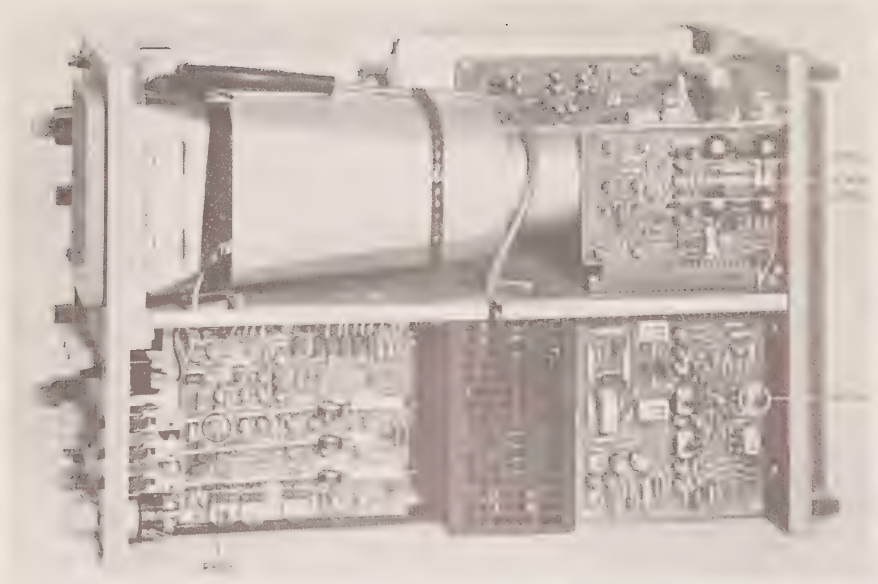

Fig. 12. Adjusting elements

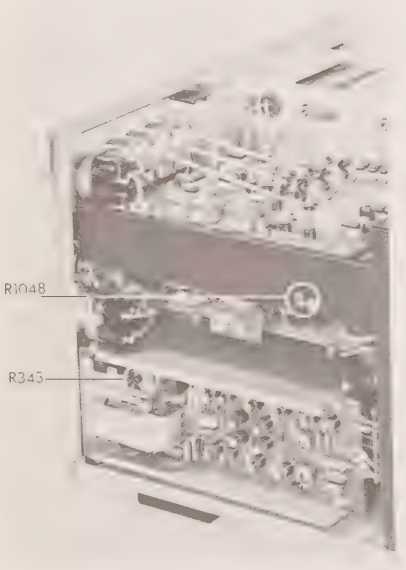

Fig. 13. Adjusting elements

Fig. 14. Adjusting elements

PHILIPS

Service manual

PM 3210 25 MHz Dual-trace oscilloscope

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VIII. Circuit description

A. CHANNEL A VERTICAL PRE-AMPLIFIER UNIT (printed-wiring board 1, Fig. 54)

General

The pre-amplifier unit provides control of the input coupling, Y deflection co-efficient and gain. Furthermore, a drift reduction circuit and a trigger pickoff stage are part of the pre-amplifier circuitry. The circuit diagram is shown in Fig. 55.

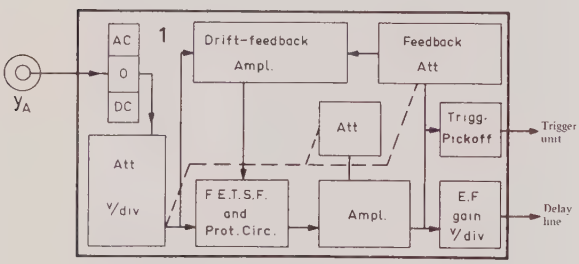

Fig. 15. Vertical pre-amplifier unit

A1. Input coupling

Input signals connected to socket Y_A BU3 can be a.c. coupled, d.c. coupled or internally disconnected. In position DC of switch AC-O-DC SK9, the input signal is coupled directly to the step attenuator. In the AC position, there is a capacitor (C26) in the signal path. This capacitor prevents the d.c. component of the input signal from being applied to the amplifier. In position 0, the signal path between the input socket and the amplifier input is interrupted, the latter being earthed. At the same time blocking capacitor C26 is discharged via R26, to prevent a possible high charge from damaging the circuit under test.

A2. Input attenuator

This attenuator is a frequency compensated, high-ohmic voltage divider with fourteen positions. The attenuator consists of four groups of three sections and one group of two sections. The first two groups (mV ranges) are identical and every next one increases the attenuation by a factor of ten.

Each attenuator section contains trimmers which can be adjusted for optimum square-wave response and others that maintain the same input impedance (1 MΩ//15 pF) for each position of switch AMPL. (SK12). The attenuator works in conjunction with a gain control in the pre-amplifier. The pre-amplifier comprises two stages. The first one provides step control of the gain in 1–2–5 sequence (see also section A4) and the second one in 1–10 sequence (see also section A5). The gain of the pre-amplifier is selected together with the relevant attenuator section, by means of switch AMPL. SK12.

A3. Input source follower

Input source follower TS26-1 and emitter follower TS28 provide a high input impedance to the step attenuator and a low impedance source to the first amplifier stage.

The attenuator, B26, GR26, GR27, R53 and R46 (Fig. 16) protect the input source follower stage.

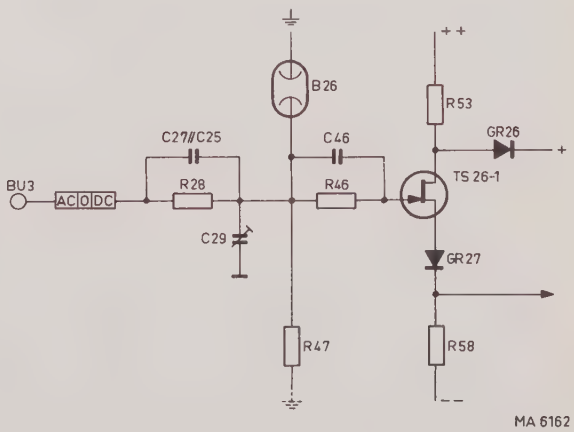

Fig. 16. Input-protection circuit

The attenuator keeps the capacitance between socket Y_A BU3 and the gate of the field-effect transistor very low in all positions of switch AMPL. SK12.

A rapid maximum voltage change on socket Y_A will, therefore, only produce a slight change in the charge of this capacitance. If there is a positive-going change, the f.e.t. can deal with it. If the change goes negative, there will be a zener voltage between the gate and the drain of the f.e.t.

As a result of this, the drain voltage drops below the cathode voltage of diode GR26 which turns off. Thus, the drain impedance will be increased with the value of resistor R53 and the discharge current through the f.e.t. is limited.

Neon bulb B26 together with resistor R46 limits the gate current in the event of a continuous input overload voltage. Capacitor C46 in parallel with R46 keeps the h.f. path clear.

Diode GR27 prevents the amplifier from being damaged when the source voltage goes negative.

A4. Amplifier with gain control in 1, 2, 5 sequence

The non-driven part of the amplifier (TS26-2) is decoupled for high frequencies, by capacitor C47. GR28 keeps the emitter potentials of transistors TS28 and TS29 on approximately the same level, when the gate of f.e.t. TS26-2 is earthed.

The signal on the emitter of transistor TS28 is amplified by transistors TS31 and TS32 and symmetrically applied to emitter followers TS33 and TS34.

Resistors R75, R76, R77 and R78 between the emitters of long-tailed pair circuit TS31-TS32 determine the amplification ratio as dictated by switch AMPL SK12.

The changes in dissipation that occur when transistors TS31 and TS32 are being driven, are limited by the RC combinations R73//C48 and R81//C51.

To suppress possible common mode disturbance, the values of collector resistors R72 and R82 are small with respect to those of the emitter bias resistors R74 and R79.

A5. Amplifier with gain control in 1, 10 sequence

This is an emitter coupled amplifier TS36-TS37 with resistors R97 (10) and R98 (1) as amplification determining components.

The current through both transistors is determined by transistor TS38 together with zener diode GR29 and resistors R108, R109 and R110. It is, therefore, possible to adjust the emitter voltage of emitter follower TS39 to earth level by means of preset potentiometer R109.

Filter R96-C52 in parallel with R97 ensures a correct step response. The changes in dissipation that occur when transistors TS36 and TS37 are being driven, are limited by RC combinations R102//C53 and R92//C54. The collectors of TS36 and TS37 are biased by resistors R91 and R103.

A6. Continuous attenuator and gain preset control

Via emitter follower TS39 whose emitter is on earth potential, and resistor R117, the signal is fed to continuous attenuator AMPL. R8.
The gain preset control GAIN ADJ. R9 in parallel with potentiometer AMPL. R8 and resistor R116 provides control of the voltage drop across resistor R117 and so of the overall gain of the pre-amplifier.

After attenuation by potentiometer AMPL. R8, the signal is fed to delay-line termination resistor R122 and via the delay-line to the vertical amplifier unit. Diode GR35 brings the d.c. level of the delay-line to earth potential.

A7. Trigger pick-off

The triggering signal is obtained from transistor TS39, i.e., before the continuous attenuator and the delay line. The triggering signal is fed to the trigger amplifier via transistor TS42. Protection zener diode GR31 provides transistor TS42 with collector voltage when another trigger source is used. Capacitor C60 is a peaking capacitor.

A8. Drift-reduction circuit

In the event of no drift phenomena in the amplifier, attenuator R131 ... R139 provides at the top of resistor R141 a voltage which is exactly equal to, but in anti-phase with, the voltage at the gate of f.e.t. TS26-1 (top of resistor R47).
This is true because attenuator R133 ... R139 is switched over together with the 1-2-5 and 1-10 amplifier, and because potentiometer R132 compensates for the tolerances of the collector resistors in the amplifier. The junction of resistors R141 and R47 will then be on earth level.

When there is a drift phenomenon, the junction of resistors R141 and R47 carries half the drift voltage. This voltage is amplified by transistors TS43-1 and -2 and, in the correct phase, applied to f.e.t. TS26-2. The resulting feedback brings the output level of the amplifier back to 0 V.
The d.c. level of this feedback is adjusted by means of potentiometer DC BAL R10.

In order to prevent the base-current of transistors TS43-1 and -2 from flowing through high-ohmic resistors R141 and R47, it is compensated for by means of potentiometer R143 and resistors R144 and R146. Resistors R147 keeps the base-impedance of transistors TS143-1 and -2 to almost equal values.
Capacitors C57 and C47 limit the drift feedback to d.c. and l.f. so that the step response of the pre-amplifier will not be affected.

B. CHANNEL B VERTICAL PRE-AMPLIFIER UNIT

As this channel is identical to channel A, the description of channel A also holds good for channel B. Components are assigned in the 200-299 range (corresponding to numbers in the 1-99 range for channel A) and in the 300-399 range (corresponding to range 100-199 in channel A).

C. DELAY LINES

The delay lines have been incorporated between the pre-amplifiers of channels A and B, and the vertical amplifier.
In order to prevent that return currents flow via the chassis of the instrument, h.f. transformers T401 and T402, and T1401 and T1402 have been provided at the beginning and the end of the delay lines.

D. VERTICAL AMPLIFIER UNIT (printed-wiring board 4, Figs. 58 & 58A)

The vertical amplifier unit comprises two identical amplifier stages, one for channel A and one for channel B, the latter of which is described.
Furthermore an electronic switch, a common amplifier stage and an output stage are part of the vertical-amplifier unit. The circuit diagram is shown in Figs. 59 & 60.

D1. Principle of series and shunt feedback amplifier

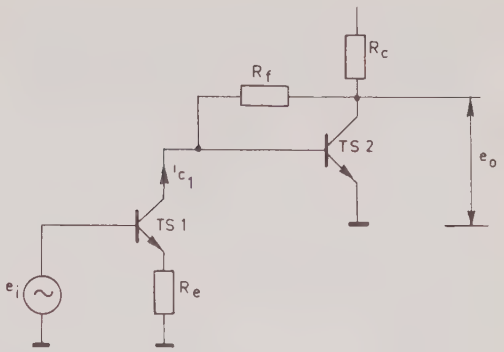

Fig. 18. Feedback amplifier

A typical example of an amplifier stage with series and shunt feedback is shown in Fig. 18.

If we neglect the base current of TS2, it will be clear that the current through R_e also flows through R_f.

The transfer ratio $\frac{i_c}{e_i}$ in a series feedback amplifier stage is approximately $\frac{1}{R_e}$.

The transfer ratio $\frac{e_o}{i_c}$ in a shunt feedback amplifier stage is approximately R_f.

So the voltage gain of the whole amplifier stage is near enough:

$$A_v = \frac{e_o}{e_i} = \frac{R_f}{R_e}$$

Thus, the gain depends only on the passive elements R_f and R_e.

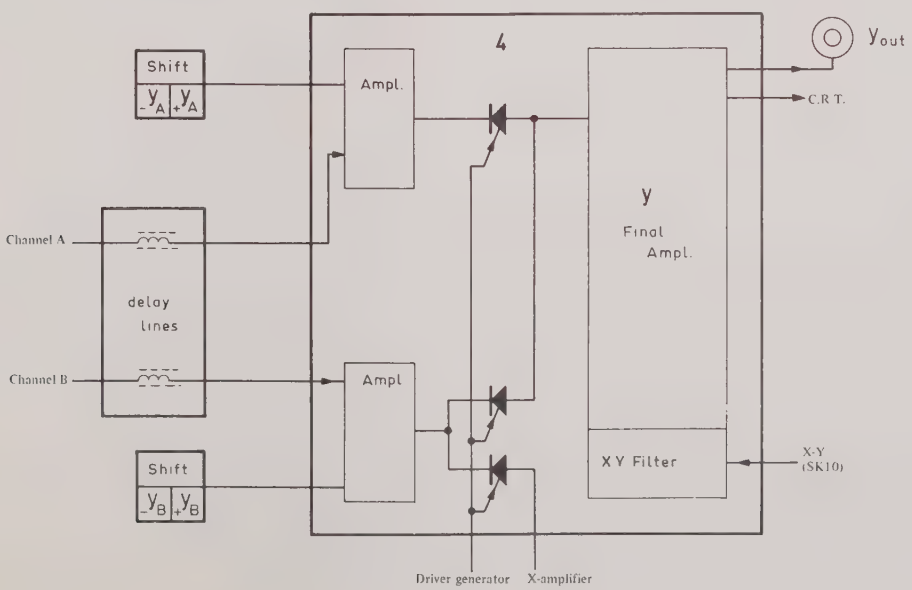

Fig. 17. Vertical amplifier unit

Note that the input impedance of the shunt feedback stage is very low due to resistor R_f, so that this stage is driven by a signal current.

Because the input of the second stage is virtually earthed, this is the ideal place to introduce an electronic switch and to apply currents of a position control without affecting the behaviour of the circuit.

D2. Amplifier stage for channel B (series-feedback amplifier)

The signal across delay-line termination resistor R401 is fed to the base of transistor TS403, via emitter follower TS401.
Transistor TS403 forms together with transistor TS404 and transistors TS414 and TS416 a symmetrical series and shunt feedback amplifier, the gain of which is determined by resistors R428 and R456 & R459.
Details of the series-feedback amplifier will be discussed in this paragraph, whereas details of the shunt-feedback stage will be dealt with in paragraph D4.
Possible step-response errors caused by the delay line are eliminated by correction elements C402/R429, C403/R431, C404/R435 and C406/R432.
The changes in dissipation that occur when transistors TS403 and TS404 are being driven, are limited by the RC combination R426//C411 and R436//C412.

Emitter follower TS402 transfers the shift voltage provided by potentiometer POSITION R15 to the base of transistor TS404. The polarity of the shift voltage can be inverted by means of switch SK15.
Potentiometer R407 allows equalization of the quiescent emitter voltages of transistors TS403 and TS404.

The signal current from the collectors of transistors TS403 and TS404 is fed to the electronic switch via either transistors TS406 & TS409, or transistors TS407 & TS409, as dictated by the position of switch SK15.

Transistors TS406 & TS409 and TS407 & TS408 allow polarity inversion of the signal and can be switched on and off in pairs, with the aid of switch SK15 which is followed by two voltage dividers (R413-422-423 and R414-419-421). Polarity inversion incurs inversion of the polarity of the shift voltage.
Preset potentiometer R407 prevents jumping of the trace when switch SK15 is operated.

D3. Electronic switch

The electronic switch, which is driven by the switch-driver unit (printed-circuit board 5), is a diode switch. Therefore, all signal voltages must be converted into signal currents in the previous amplifier stage, and the input impedance of the common amplifier must be very low.

The electronic switch offers various possibilities, as there are two signal-current channels: A and B.
These currents can be fed to either the common amplifier or the horizontal amplifier, depending on the driving voltage which opens or closes the diode switch.
The driving voltages of the switch-driver unit are applied to emitter followers TS411 & 412 and TS1411.

If the voltage on the emitters of TS411 & 412 is low with respect to the input voltage of the common amplifier, diodes GR407 & 408 are cut off. Then the signal current is fed to the input of the common amplifier via the conducting diodes GR406 & 409 (Fig. 19).

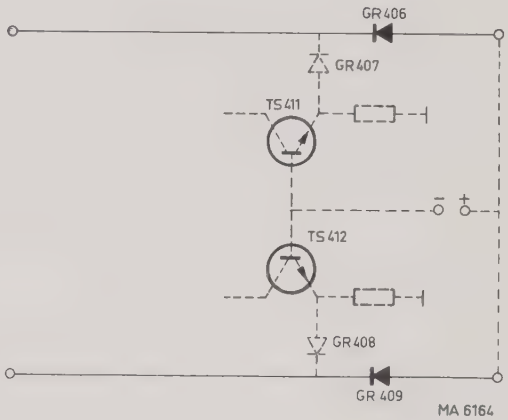

Fig. 19.

The same applies to the emitter voltage of transistor TS411. If this voltage is low, the signal currents reach the input of the common amplifier (Fig. 20).

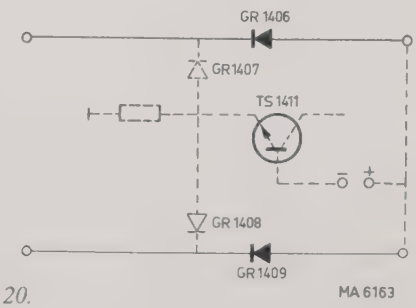

Fig. 20.

However, if the base voltage of transistor TS1411 exceeds the input voltage of the common amplifier, diodes GR1406 and GR1409 are cut off and diodes GR1407 and GR1408 are conductive. The signal current of channel A cannot reach the input of the common amplifier any longer.

The conducting diodes GR1407 & 1408 short-circuit this signal (Fig. 21).

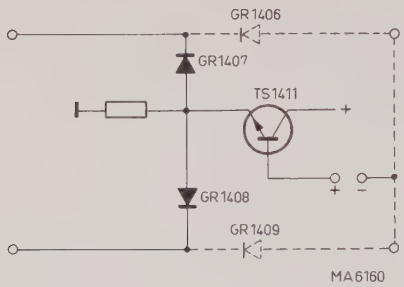

Fig. 21.

The same explanation applies, roughly speaking, to channel B. If the base voltages of transistors TS411 & 412 exceed the input voltage of the common amplifier, diodes GR406 & GR409 are cut off and no signal current is fed to the common amplifier.
The signal current then flows via conducting diodes GR407 & 408 through transistors TS411 & 412.
Depending on the anode voltage of diodes GR403 & 404 the signal can be either short-circuited via these diodes, or applied to the horizontal amplifier via resistors R446 & 447.

If the anode voltage exceeds the input voltage of the horizontal amplifier, the signal is short-circuited. If there is no voltage applied via point 25 of switch SK10, resistor R444 causes the anode voltages of diodes GR403 & 404 to be negative and the signal current is fed to the horizontal channel (Fig. 22).

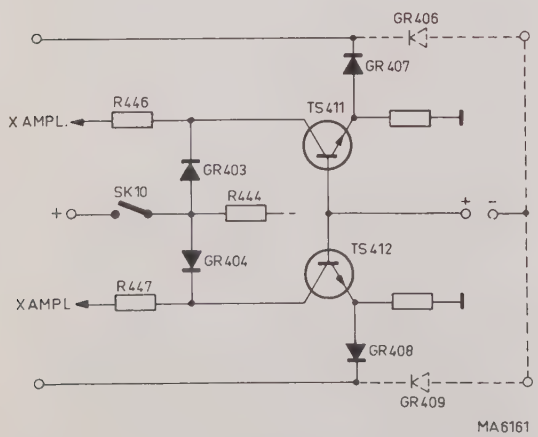

Fig. 22.

Summarizing there are the following possibilities:
1. Base TS1411 negative (Fig. 20):
   signal current channel A fed to vertical output stage.
2. Base TS1411 positive (Fig. 21):
   signal current channel A short-circuited.
3. Bases TS411 & 412 negative (Fig. 19):
   signal current channel B fed to vertical output stage.
4. Bases TS411 & 412 positive (Fig. 22):
   signal current channel B does not reach the vertical output stage, and can, depending on the voltage at point 25 SK10:
   a. be short-circuited via conducting diodes GR403 & 404 (25 SK10 positive).
   b. be fed to the horizontal amplifier via R446 & 447 (25 SK10 negative).

D4. Common amplifier stage (shunt-feedback amplifier)

This amplifier comprises transistors TS413 ... TS417.

The use of transistors TS413 & 417 which act as emitter followers, also provide a low-ohmic output impedance. This enables an efficient driving of the output stage and the possibility of presenting the signal on socket Y_{OUT} BU7.

The input signal for the common amplifier stage can be obtained as described in para. D2 from pre-amplifier A, pre-amplifier B, or from A and B.

In position A or B, the input of the common amplifier receives both the signal current and the quiescent current of the relevant channel.

In position A + B, the quiescent current will reach double the value and also the output capacitance of the electronic switch will increase slightly. To eliminate errors caused by this phenomenon, resistors R453 & 454 are, via point 24 of switch SK10, connected to the positive voltage that supplies the quiescent current of the 2nd channel.
As resistor R455 is then also connected to the positive voltage, diode GR411 is cut off and the output capacitance of the electronic switch will decrease with the value of capacitor C409.

D5. Output stage

The output signal of the common amplifier is fed to the vertical deflection plates via the output stage. This stage is a series and shunt-feedback amplifier of the type described in para. D1. The gain determining components are R616 and R623 & R632.

a. The series-feedback stage, consists of two emitter-coupled transistors TS602 & 603. The series-feedback is adjusted with potentiometer R616 so that the gain of the output amplifier can be adapted to the sensitivity of the c.r.t.

The bias current is supplied by transistor TS601 and adjusted with potentiometer R602.
Diodes GR601 and GR602 prevent cutting off of the transistors at large driving signals.

b. The shunt-feedback stage, consists of p.n.p. transistors TS606 & TS 607 and complementary n.p.n. transistors TS604 & 608. The shunt-feedback is obtained with resistors R623 & 632.
The current in this stage is determined by the base-bias resistors R618 & 619 of transistor TS608, together with emitter resistors R621 & 637.
These transistors work for a.c. voltages only and receive their driving via capacitors C606 & 612. Resistor R627 determines the emitter voltage and thus the base voltage of transistors TS606 & 607.

c. An XY filter, has been included between the series- and shunt-feedback stage and consists of resistors R617, R628 and R614, and of capacitors C603 and C604.

The XY filter is switched in by means of reed relay RE601 which is energized via resistor R615, when the XY push-button of switch SK10 is operated.
The XY filter equalizes the frequency and phase response of the vertical amplifier to that of the horizontal amplifier when the oscilloscope is used for XY measurements.

E. TIME-BASE UNIT (printed-wiring board 3, Fig. 61)

General

This unit comprises the following circuits: the trigger-pulse shaper, the time-base generator and the trigger auto circuit. The circuit diagram is shown in Figs. 62 & 63.

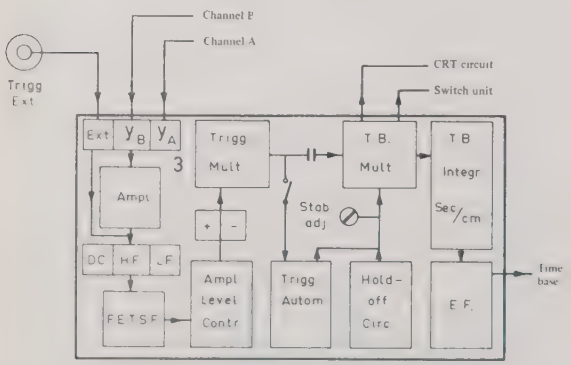

Fig. 23. Time-base unit

E1. Trigger-Pulse shaper

E1a. Input amplifier

The triggering signal from either channel A or channel B can be fed to the emitter of transistor TS702 via switch Y_A - Y_B -EXT SK4. As no signal current is lost in the base of transistor TS702, the amplified input signal is available across resistors R719 and R721.

E1b. Filters

In position Y_A or Y_B of switch Y_A - Y_B -EXT SK4 the signal is via emitter follower TS703, applied to the high-ohmic filters that are switched in by means of switch LF-HF-DC SK2 (Fig. 24).

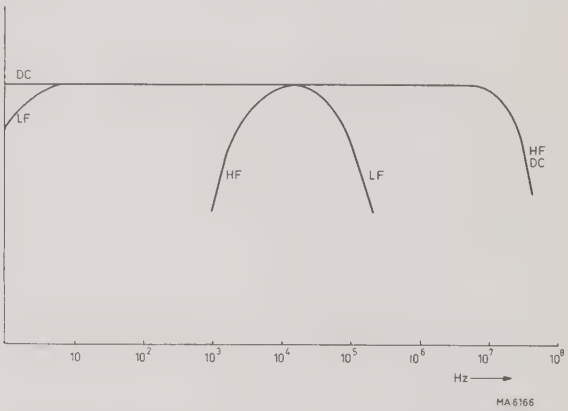

Fig. 24. Frequency response of the trigger amplifier

In the LF position, the triggering signal is coupled via filter C706 - R727 - C707 which forms a bandpass filter for frequencies from 10 Hz to 10 kHz.

In the HF position, the triggering signal is coupled via high-pass filter C708 - R728 which blocks frequencies below 10 kHz.

In the DC position, the triggering signal is directly coupled to the differential amplifier.

In the AUTO position of switch LEVEL SK5, the triggering signal is a.c. coupled as capacitor C709 is in the signal path.

In position EXT of switch Y_A - Y_B -EXT SK2, the triggering signal is not taken from emitter follower TS703, but from input socket EXT. TRIGG. BU1.
The high-ohmic filters followed by f.e.t. source follower TS704-1 provide a high input impedance so that the triggering-signal source is neither loaded nor affected.
Diodes GR701 and GR702 protect the input circuit by limiting too high an external triggering signal.

E1c. Differential amplifier

Via impedance transformer TS704-1, the triggering signal is fed to the base of transistor TS706. This results in voltages with equal amplitude but in anti-phase on the collectors of transistors TS706 and TS707. Selecting one of these voltages by means of switch +/−SK3 allows triggering on either the positive- or the negative-going edge of the signal.

Potentiometer LEVEL R1 allows, via f.e.t. source follower TS704-2, continuous control of the d.c. level on the base of transistor TS707. The level setting determines which part of the triggering signal will be amplified. Thus, the trigger level is determined by the setting of potentiometer LEVEL R1.

In the AUTO position (switch LEVEL SK5 pulled) the voltage range on the base of transistor TS707 is limited by connecting R758 in parallel to potentiometer LEVEL R1.

E1d. Pulse-shaper

The amplified triggering signal switches trigger pulse-shaper TS711 & 712. In the event of a repeating triggering signal, there will be a square-wave voltage with a constant amplitude and rise-time on the collector of transistor TS712 (Fig. 25). By means of capacitor C801 and resistor R802, this voltage is differentiated into positive and negative pulses.

Transistor TS801, which is normally cut off, blocks the negative pulses, whereas the positive pulses are converted into negative spikes which are applied to the time-base generator via capacitor C804.

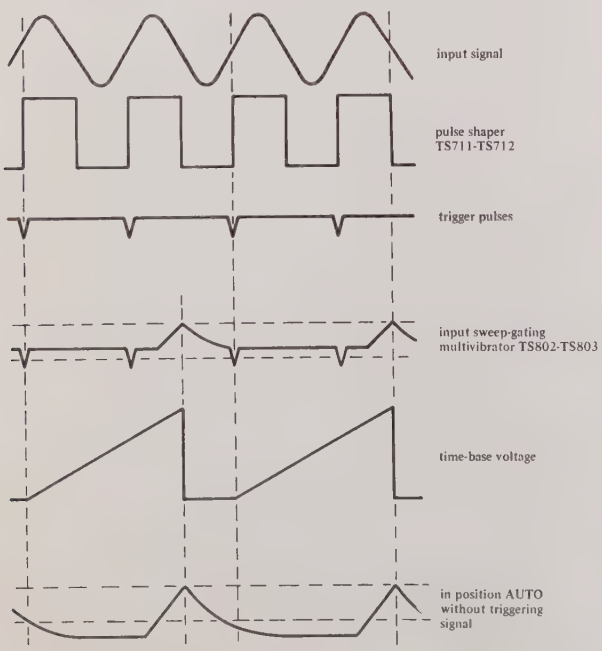

Fig. 25. Pulse shapes

E2. Time-base generator

The time-base generator consists of a bootstrap integrator driven by sweep gating multivibrator (s.g.m.) TS802 & 803.

For the explanation of the diagram, we assume the following condition of the s.g.m.:
transistor TS802 cut off
transistor TS803 conductive

Discharge transistor TS804 is blocked and time-base capacitor C832 is charged with a constant current which is determined by resistor R871.

The constant charging current is obtained by feedback in the bootstrap integrator via transistors TS808 & 809; as a result the voltage across resistor R871 has a constant value.

The direct current through transistor TS808 can be adjusted with both potentiometer TIME/cm R4 and potentiometer R803. In this way it is possible to vary the constant voltage across resistor R871 and thus the time-coefficient. Potentiometer TIME/cm R4 is the continuous time-coefficient control, whereas R803 is an internal pre-set potentiometer.

Via transistors TS806 & 807, diode GR801 and transistor TS811, the linearly increasing voltage across capacitor C832 is fed back to s.g.m. TS802 & 803, causing the latter to switch over to the state:
transistor TS802 conductive
transistor TS803 cut off

Transistor TS804 becomes conductive and capacitor C832 is discharged. The voltage at the input of the s.g.m. drops to a level on which the s.g.m. just does not switch over. This level is adjusted by means of potentiometer STAB R6.

The decrease of the voltage level on the s.g.m. input is delayed by hold-off capacitor C821, so that capacitor C832 can discharge completely. Thus the s.g.m. can switch over only if capacitor C832 has been completely discharged.

On arrival of the next trigger pulse, the s.g.m. switches over, transistor TS804 is cut off and capacitor C832 is charged.

With the aid of switch TIME/cm SK6, 21 different time-coefficients can be set by selecting different capacitors from the range C823 ... C832 and charging resistors from the range R861 ... 871. The time-coefficient is calibrated when potentiometer TIME/cm R4 is in the fully clockwise position.

The sawtooth voltage is taken off via voltage divider R838-839 across zener diode GR801, so that the voltage lies around zero level.
The unblanking voltage is taken off from the collector of transistor TS802.

In position XY of the mode selector SK10, the +23 V supply of both pulse generator and time-base generator is replaced by a negative voltage.

As the supply of resistor R854 ceases, the input voltage of the s.g.m. drops, so that transistor TS802 is cut off and its collector supplies the unblanking signal.

Because the base voltage of transistor TS807 cannot exceed its collector voltage and the voltage on the time-base capacitor cannot become positive, the s.g.m. is not switched back.

On the collector of transistor TS803 the signal is taken off, which switches the vertical output amplifier at every time-base sweep between pre-amplifier A and B, in position ALTERNATE of mode selector switch SK10.

E3. Automatic trigger circuit

In the level position of switch LEVEL SK5, the base of transistor TS812 is connected to the −23 V supply, so that transistor TS812 is cut off.

In the automatic position, transistor TS812 draws base current via resistor R849, in the event of no trigger pulses. The collector current lowers the level at the input of s.g.m. TS802 & 803, so that the s.g.m. switches over after the fly-back of the time-base: the time-base generator is free-running.

In the event of a triggering signal, the base of transistor TS812 becomes negative again as a result of the square-wave voltage on its collector, which is rectified by circuit C813, GR806, GR804 and C814. Consequently, transistor TS812 is cut off. Thus, the time-base generator is not free-running any longer and will only be started by a trigger pulse, applied via C804.

F. HORIZONTAL AMPLIFIER UNIT (printed-wiring board 7, Fig. 64)

General

The horizontal amplifier unit comprises a pre-amplifier and an output amplifier. The circuit diagram is shown in Fig. 65.

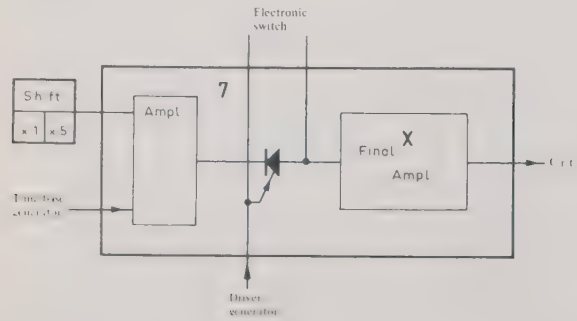

Fig. 26. Horizontal amplifier unit

F1. Pre-amplifier

The pre-amplifier is a series and shunt-feedback amplifier of the type described in para. D1. Gain determining elements are R917 and R924 & 931. The pre-amplifier is driven on the base of transistor TS901 by the output signal of the time-base generator.
A d.c. voltage, adjustable with potentiometer POSITION R7, is applied to the base of transistor TS902.

If switch MAGN. SK8 is pulled to the x 5 position, diodes GR901 & 902 which are normally cut off, start conducting via switch SK8. Consequently resistor R904 is connected in parallel to R917, resulting in a gain increase of 5 x.

If diodes GR906 & 907 are cut off and diodes GR908 & 909 are conductive, the series-feedback stage is connected to shunt-feedback stage TS903-906 & TS904-909. Resistors R924 and R931 are the feedback resistors.

In position XY of mode selector SK10, resistor R922 is connected to the +23 V supply so that diodes GR906 & 907 start conducting and diodes GR908 & 909 are cut off.
Amplifier stage TS903 & 906 and TS904 & 909 is then via diodes GR911 & 912 connected to channel B of the vertical amplifier.

F2. Output amplifier

The gain of emitter-coupled amplifier stage TS907 & 908 is determined by potentiometer R944 and resistor R947.
By means of potentiometer R944, the gain of the horizontal amplifier is adapted to the sensitivity of the c.r.t. The phase- and frequency response of the horizontal amplifier can be corrected with filter C906-R946.

The bias current for this stage is supplied by transistor TS911 and can be adjusted by potentiometer R959.

Zener diodes GR916 & 917 bridge the difference in voltage level between amplifier stage TS907 & 908 and the output stage with transistors TS912 ... 914 and TS916 ... 918.

The voltage feedback of the output stage is obtained from resistors R961 & 967. The current in this stage is determined by the base biases of transistors TS914 (by resistors R968 & 969) and TS918 (by resistors R976 & 977), in conjunction with emitter resistors R983 & 984. These transistors work for a.c. voltages only and obtain their signal via capacitors C911 & 912.

Resistor R985 determines the emitter voltage and thus the base voltage of transistors TS916, TS912, TS917 and TS913.

G. SWITCH UNIT (printed-wiring board 5, Fig. 66)

General

The switch unit comprises a blocking oscillator, a multivibrator and the mode selector switch SK10. The circuit diagram is shown in Fig. 67.

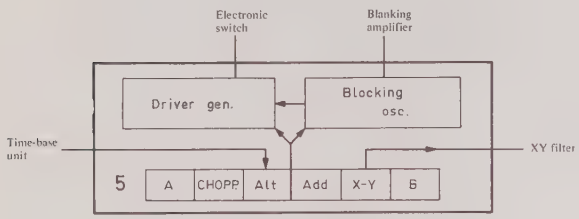

Fig. 27. Switch unit

G1. Blocking oscillator

The blocking oscillator consists of transformer T501 in conjunction with transistor TS506. Winding S1 of the transformer (in the collector circuit of transistor TS506) is coupled to the winding S4 in the base circuit of TS506.

If the potential of the base winding is sufficiently negative to open the transistor, the current in the transistor and the voltage across C514/R537 increases as a result of the foreward coupling.

This process continues until transformer T501 is saturated and the base drive ceases. Then there flows no current in the transistor any longer until capacitor C514 has discharged via resistor R537. Thus, this capacitor and resistor determine the frequency of the oscillator.

It is possible to switch the blocking oscillator on or off via voltage divider R527-528. When R527 is connected to earth via point 11SK10, the base of transistor TS905 becomes negative with respect to its emitter and the oscillator is operative.

If resistor R527 is not connected to earth, the base potential of transistor TS506 is equal to its emitter potential and the oscillator becomes operative only at incoming pulses which are large enough to open the transistor. These pulses are supplied by winding S3 of the transformer in conjunction with transistor TS507.

The base of the latter receives a positive pulse via resistor R816 at each fly-back of the time-base, and the transistor then starts conducting. The collector current which flows through winding S3 drives the blocking oscillator.

To prevent the time-base generator from affecting the frequency when the oscillator is free-running, the emitter of transistor TS507 is, in that event, connected to the positive supply voltage via resistor R529 and point 14 of switch SK10. Consequently, transistor TS507 is blocked to such an extent that the time-base pulses have no influence on it at all.

Transformer winding S3 supplies in all above-mentioned events a negative pulse which is via resistors R535 and R530 fed to the blanking system and the cathode of the c.r.t. The blanking system suppresses the electron beam in the c.r.t. during the switching over of the blocking oscillator.

Summarizing there are the following possibilities.

1. The oscillator is free-running

Point 11SK10 is connected to earth and point 14SK10 is connected to the positive supply voltage. Across resistor R530 there are negative blanking pulses (GR511 clips the positive side).

2. The oscillator is inoperative

Point 11SK10 is connected to earth and point 14SK10 is connected to the positive supply voltage.

3. The oscillator is driven by the time-base generator

Point 11SK10 is disconnected from earth. Each time-base fly-back pulse opens transistor TS507 so that the oscillator becomes operative.

Winding S2 of transformer T501 supplies the output pulse of the oscillator to the multivibrator via a phase delaying network. This network consists of L501, R525 and C505, and makes sure that the blanking pulses suppress the electron beam at the correct moment.

G2. Multivibrator

The bistable multivibrator comprises the transistors TS502 and TS503. Both transistors are coupled by means of resistors R511 & 517 and R514 & 513, which make sure that the conducting transistor keeps the non-conducting transistor in the cut-off state.

Assume that transistor TS502 is conducting. Then its collector voltage almost equals its base voltage. Consequently, diode GR504 is on the verge of conducting, whereas diode GR506 is hard off owing to the positive collector voltage of transistor TS503.

A negative pulse applied to the blocking oscillator will reach the diodes via capacitors C504 and C506.

Diode GR506 remains cut off and GR504 starts conducting so that the negative pulse arrives at the base of transistor TS502 and turns this transistor off. Consequently, the collector voltage of transistor TS502 becomes positive and transistor TS503 starts conducting.

This process is repeated at each entering pulse of the blocking oscillator.

Zener diodes GR507 and GR508 bring the d.c. level on the collector of transistors TS502 & 503 and thus on the emitters of transistors TS501 & 504, on the value required for the electronic switch.

Diodes GR501 & 502 prevent top errors of the output square-wave voltage, as these errors might adversely affect the proper working of the electronic switch.

Resistors R518 & 519 at the bases of transistors TS502 & 503 enable selection of a preference state for the bistable multivibrator.

If point 35 of switch SK10 is connected to the positive voltage, transistor TS503 starts conducting and transistor TS502 is cut off. This means that the output conditions of the switch unit are such that the signal of channel B is displayed.

If, on the other hand, point 6 or point 29 of switch SK10 is connected to the positive voltage, channel A will be displayed.

If point 23 of switch SK10 becomes positive, diodes GR508 & 509 which were cut off via resistor R521, start conducting. Both transistors TS502 and TS503 draw current so that the output voltages of transistors TS501 and TS504 will be equal and negative. This occurs in position ADDED of switch SK10: both channel A and channel B are connected to the vertical output amplifier.

G3. Mode selector switch SK10

By means of mode selector switch SK10, the desired channel or channel combination can be displayed.

Summarizing, together with the previous descriptions of the electronic switch, multivibrator, horizontal and vertical amplifier, this means that:

a. **In position A**, the blocking oscillator is blocked, no blanking pulse is fed to the c.r.t. and the multivibrator is set to the correct position.

b. **In position CHOPPED**, the blocking oscillator becomes operative and is not affected by the time-base generator. The electronic switch is driven by the blocking oscillator via the multivibrator and the electron beam is suppressed during the switching over.

c. **In position ALTERNATE**, the blocking oscillator is driven by the fly-back of the time-base, so that signals of both vertical channels are displayed in turns.

d. **In position ADDED**, the blocking oscillator is inoperative and no blanking pulse is applied to the c.r.t. Both multivibrator transistors are conductive so that both channel A and channel B supply their signals via the common amplifier to the output amplifier. At the same time, the quiescent current for the extra amplifier is supplied via point 24 of switch SK10, and the capacitive change in the electronic switch is eliminated.

e. **In position XY**, the blocking oscillator is inoperative and no blanking pulse is applied to the c.r.t. The time-base generator cannot operate any longer as its power supply is interrupted via point 25 of switch SK10. Channel A is connected to the vertical output amplifier and channel B to the horizontal amplifier.

f. **In position B**, the blocking oscillator is inoperative and no blanking pulse is applied to the c.r.t. The multivibrator is set to the correct position.

H. C.R.T. CIRCUITRY & POWER SUPPLY (printed-wiring boards 8 & 6, Figs. 70 & 68)

General

The c.r.t. circuitry provides control of the intensity, focus and astigmatism, and correction possibilities for barrel and pin-cushion distortion and the position of the trace.
The blanking circuit is also part of the c.r.t. circuitry.
The power supply comprises the mains transformer, stabilized supply and converter, the calibration voltage generator and the circuit for the graticule illumination.
The circuit diagrams are shown in Figs. 69, 71 & 73.

H1. Mains transformer

Mains transformer T1101 has four primary windings which, by means of voltage adapter SK16, can be combined in such a way that the instrument can be used with voltages of 245, 220, 200, 145, 125, and 110 V. The mains input is provided with an interference suppression filter.

The voltage on secundary winding 9-10 is full-wave rectified. The resulting positive d.c. voltage is applied to the voltage stabilizer and the converter.

In addition, transformer winding 11-12 supplies the heater voltage for the c.r.t. This voltage lies on approximately the same d.c. level (−1600 V) as the cathode, in order to prevent flashover between cathode and filament.

H2. Voltage stabilizer

The output voltages of the converter are stabilized. The stabilization is effected by comparing a voltage which is proportional to the +23 V converter voltage, with a reference voltage supplied by zener diode GR1106, in a differential amplifier. The difference, if any, is applied to the series regulator TS1102 which compensates for the difference.

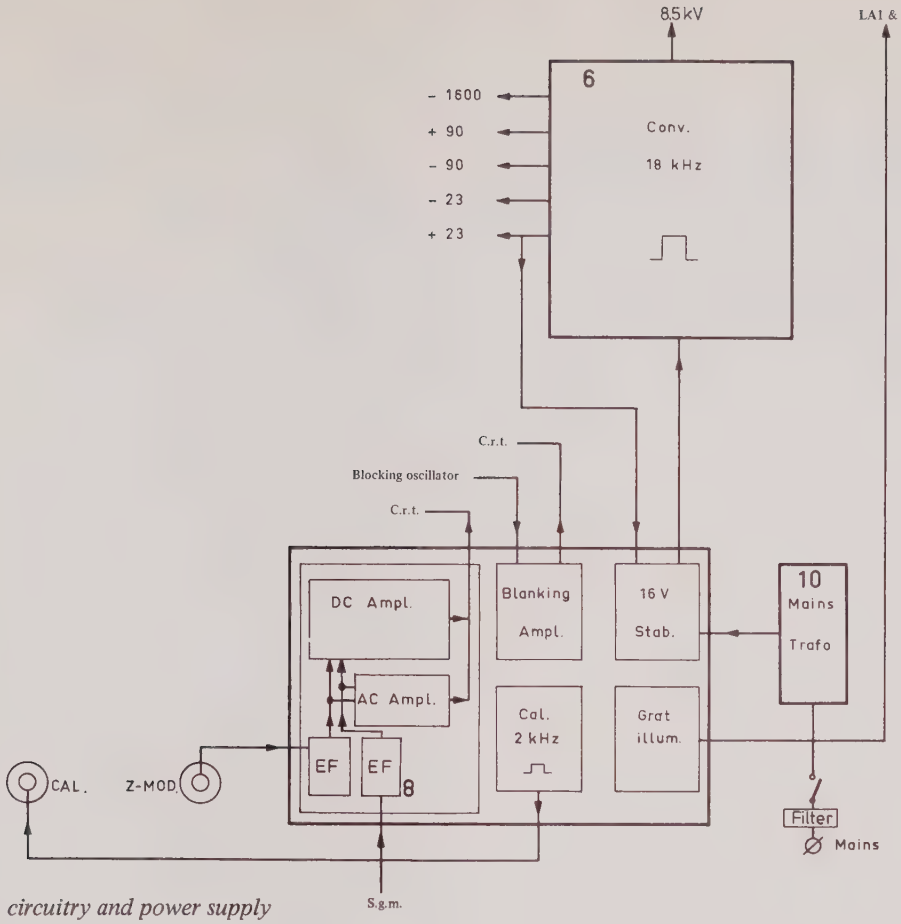

Fig. 28. C.r.t. circuitry and power supply

Potentiometer R1114 allows accurate adjustment of the +23 V converter voltage. The hum can be minimized by means of potentiometer R1118.

The converter consists of an inductive multivibrator (transistors TS1101 & 1102 and the primary of transformer T1201) operating at a frequency of approx.18 kHz. After rectifying the secundary voltages of transformer T1201, the stabilized voltages +23 V (reference voltage), −23 V, +85 V, −85 V, −1600 V and the high voltage +8500 V are obtained.
If one of the supply voltages is short-circuited, the converter comes into a safe state of power consumption. Thus, the power supply of the instrument is protected against short-circuits.

H3. Calibration voltage

The calibration voltage generator consists of free-running multivibrator TS1108 & 1109. The generator frequency is approximately 2 kHz. The amplitude of the generated square-wave voltage is kept at a constant value by means of zener diode GR1107. The exact value of the calibration voltage is set with the aid of select-in-test resistors R1136 & 1138.

H4. Illumination circuit

The graticule of the c.r.t. can be illuminated by means of bulbs LA1 and LA2.
The intensity can be varied with the aid of potentiometer ILLUM R5 which controls the collector current (which is the current through the bulbs) of transistor TS1104.

H5. C.r.t. circuit

By means of potentiometer INTENS R2 the brightness of the display can be continuously controlled. The maximum beam current is set by potentiometer R1021. The control range of both potentiometers is set with select-in-test resistors R1018 & 1019.

The display can be focussed by potentiometer FOCUS R3, the control range of which is set by select-in-test resistor R1013.
Astigmatism is corrected with the aid of potentiometer R1044.

With the aid of potentiometer R1047 barrel and pin-cushion distortion is corrected.

Potentiometer R1048 provides trace rotation control and allows the time-base line to be accurately aligned with the horizontal graticule lines.

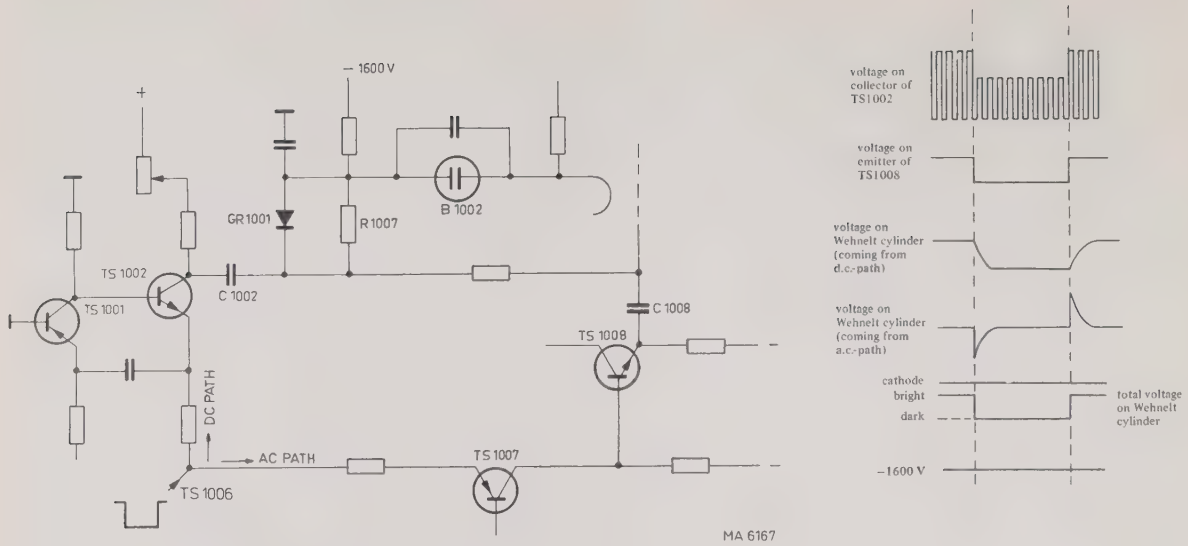

Fig. 29. Simplified diagram of the blanking circuit

H6. Blanking circuit (see Fig. 29)

The blanking circuit blanks the c.r.t. during the fly-back of the time-base and unblanks the c.r.t. constantly in position XY of mode selecter switch SK10.

The blanking circuit also enables external Z modulation, and intensity control.

H6.1. Blanking of the time-base fly-back

The blanking circuit operates on a low voltage level and comprises an a.c. and a d.c. path.

– The a.c. components of the blanking signal are fed directly to the Wehnelt cylinder of the c.r.t. via H.T. capacitor C1008.
– The d.c. components are modulated on a carrier and via H.T. capacitor C1002 transferred to demodulator circuit GR1001-R1007 in the c.r.t. circuit.

H6.2 Unblanking of the time-base sweep

Transistor TS1006 is driven on its base by the collector signal of transistor TS802 in the s.g.m. Transistor TS1006 operates in the emitter-follower configuration.

– **A.C. Path**: Transistor TS1006 drives transistor TS1007 on its emitter. The amplified blanking signal on the collector of TS1007 is passed to the Wehnelt cylinder of the c.r.t. via emitter follower TS1008 and capacitor C1008.

– **D.C. Path**: For the d.c. component of the blanking signal, the signal of oscillator TS1001 & 1002 is used. The oscillator signal (frequency approx. 150 kHz) is modulated with the d.c. component (current drive from transistor TS1006). The amplified modulated signal on the collector of transistor TS1002 is via capacitor C1002 fed to demodulator GR1001-R1007.

The a.c. and d.c. amplifications are equallized by means of potentiometer R1001.

H6.3 External Z modulation

Input socket Z MOD. BU8 is d.c. coupled to the blanking circuit via emitter follower TS1004.
This emitter follower drives transistors TS1007 & 1002 in the same way as decribed above.
The input transistor TS1004 is protected against overload, by means of resistor R1039 which limits the base current in the event of too high a positive input voltage, and by diode GR1004 which starts conducting at negative input voltages exceeding –24 V.

H7. Intensity control

Potentiometer INTENS. R2 allows control of the current through oscillator transistor TS1002 so that the oscillation amplitude on its collector varies. After demodulation by GR1001-R1007, a variable positive d.c. voltage is produced which drives the Wehnelt cylinder of the c.r.t.
R1021 allows adjustment of the maximum beam current when potentiometer INTENS R2 is set to maximum.
B1002 in the c.r.t. circuit is connected in such way that the c.r.t. is blanked if the oscillator TS1001 & 1002 becomes inoperative (between the cathode and the Wehnelt cylinder of the c.r.t. there is the working voltage of neon bulb B1002).

H8. Blanking during switching in position CHOPPED

Transistor TS1003 is driven by a negative pulse from blocking transformer T501.
The positive pulse which then arises on the collector of TS1003 is applied to the c.r.t. circuit by means of transformer T1001.

Level diode GR1003 makes sure that the cathode level of the c.r.t. is not affected by the positive pulses of the blanking circuit and also that possible negative ringings of transformer T1001 are not transferred.

IX. Dismantling the instrument

IMPORTANT:

– In this instrument very high voltages are generated so that you must take due care when you are working on the interior of the instrument.
– Switch off the instrument at least one minute before you start replacing parts.

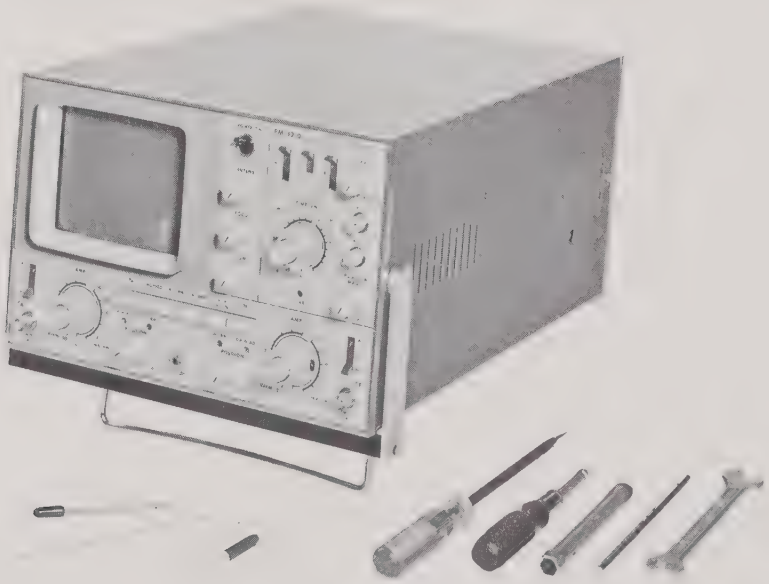

Fig. 30. Dismantling

A. REMOVING THE BEZEL AND THE MEASURING GRATICULE

– Pull the lower part of the bezel back and lift it of the hinge.
– Subsequently the contrast filter and the measuring graticule can be removed.

B. REMOVING THE KNOBS

1. The knobs of R2, R3 and R5 can be pulled off the shaft.
2. Single knobs (Fig. 31)
   Remove cap A.
   Slacken screw B.
   Pull the knob off the shaft.
3. Double knobs (Fig. 31.)
   – Remove cap A and screw B.
   – Pull the innter knob off the shaft.
   – Slacken nu C.
   – Pull the outer knob off the shaft.

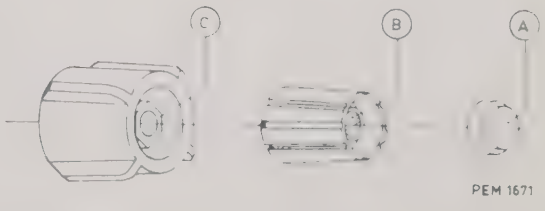

Fig. 31. Removing the knobs

C. REMOVING THE TOP COVER

– Remove the two screws with which the handle is attached and the two screws near the rear panel.
– Lift off the cover.

D. REMOVING THE BOTTOM PLATE

– Remove the five screws on the bottom plate.
– Lift off the bottom plate.

E. REMOVING PRE-AMPLIFIER UNIT 1 (Fig. 32)

– Remove the knobs of R8 and SK12 (see para. B).
– Remove the fixing nut of the shaft of SK12.
– Slacken screw 2.
– Unplug the five connectors 3.
– Remove the unit.

Pre-amplifier unit 2 can be removed in a similar way.

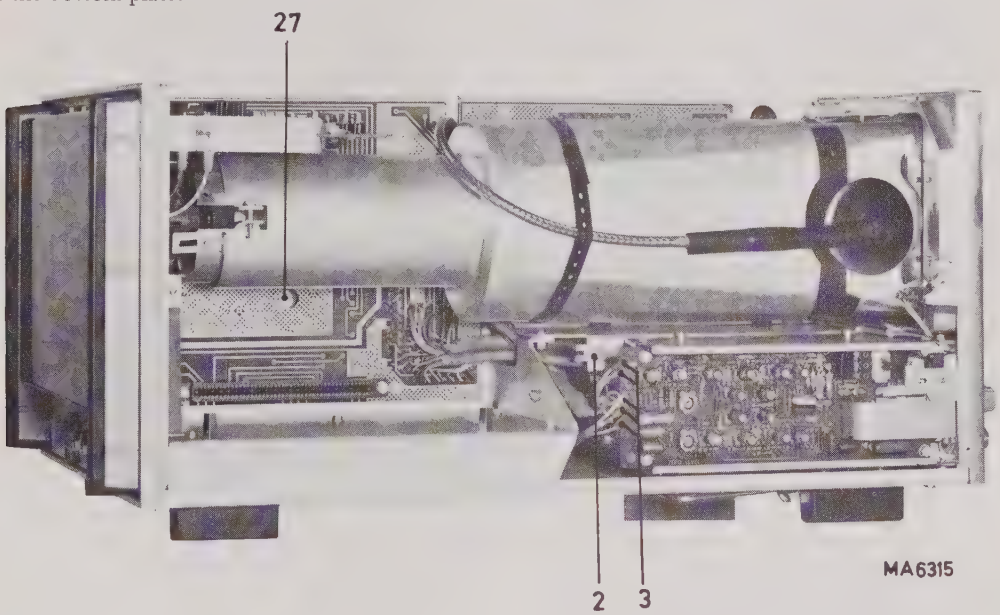

Fig. 32. Dismantling; left-hand side view

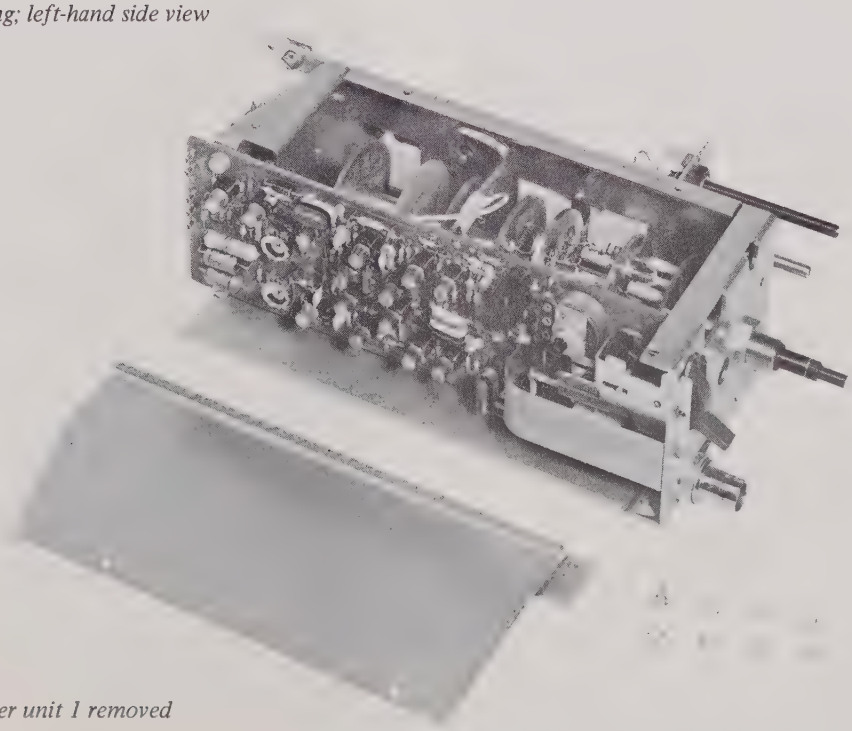

Fig. 33. Pre-amplifier unit 1 removed

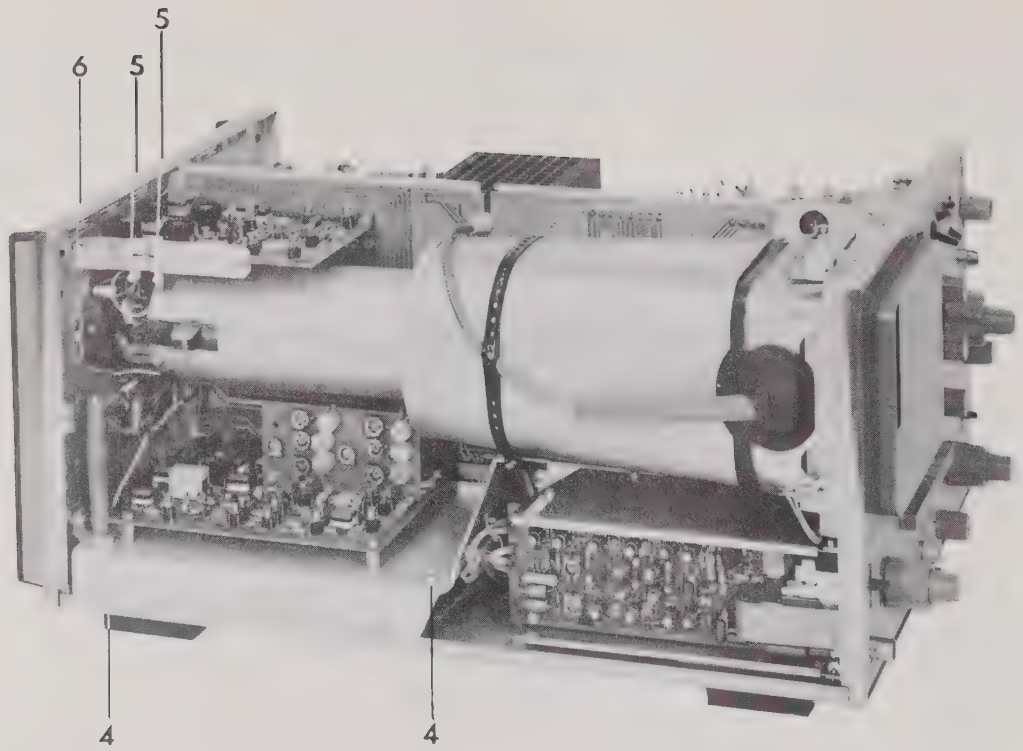

Fig. 34. Dismantling; left-hand side view

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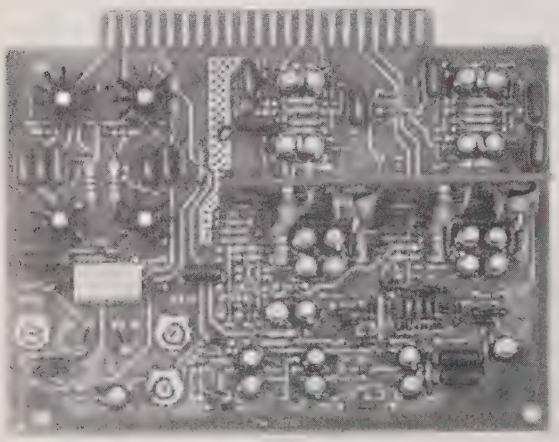


Vertical amplifier unit 4 removed

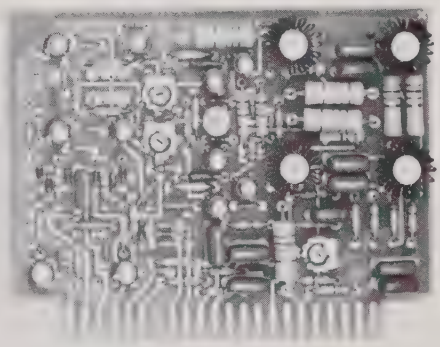


Fig. 36. Horizontal amplifier unit 7 removed

F. REMOVING VERTICAL AMPLIFIER UNIT 4 (Fig. 34)

– Remove the two screws 4
– Remove the unit.

G. REMOVING HORIZONTAL AMPLIFIER UNIT 7 (Fig. 34)

– Unplug the two connectors 5.
– Slacken screw 6.
– Remove the unit.

H. REMOVING TIME-BASE UNIT 3 (Fig. 37)

– Remove the knobs of R4, R1 and SK6 (see para. B).
– Remove screw 8 and strip 9.
– Unplug the twelve connectors 10 and the two connectors 11.
– Remove screw 12 and the two screws 13.
– Remove the unit.

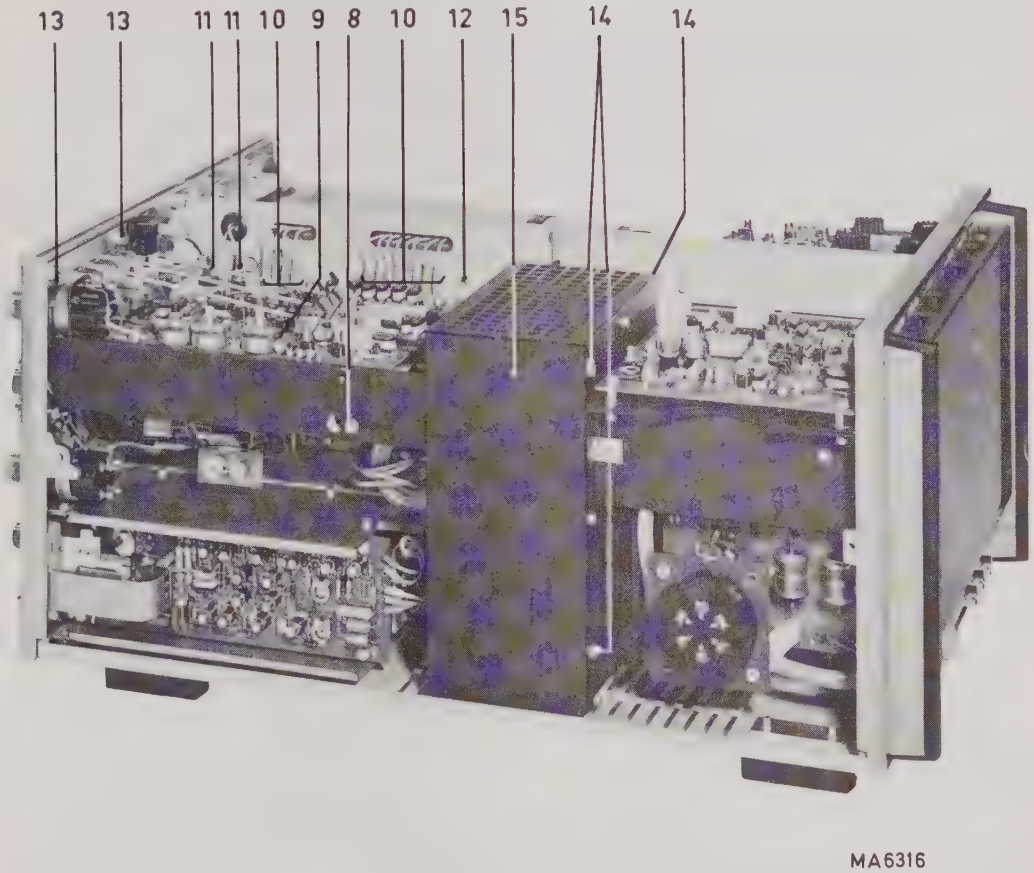


Fig. 37. Dismantling; right-hand side view

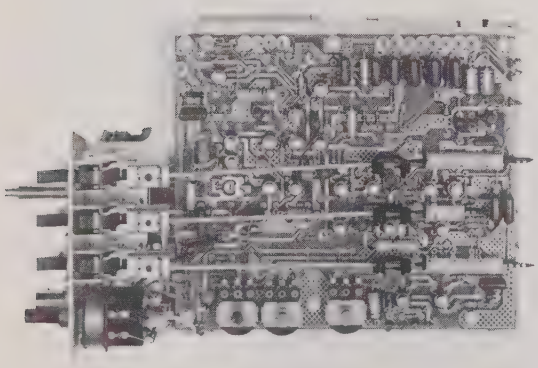


Fig. 38. Time-base unit 3 removed (unit side)

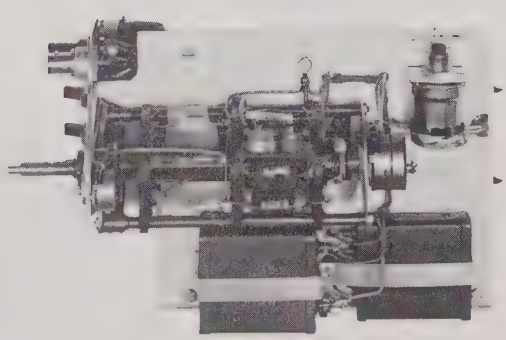


Fig. 39. Time-base unit 3 removed (switch side)

J. REMOVING CONVERTER UNIT 6 (see Figs. 37 & 40)

– Remove screw 8 and strip 9.
– Remove the three screws 14.
– Remove H.T. unit cover 15.
Release the H.T. connection on the c.r.t. and discharge cable and connection point.
– Unplug six connectors 16.
– Remove screw 17.
– Remove the unit.

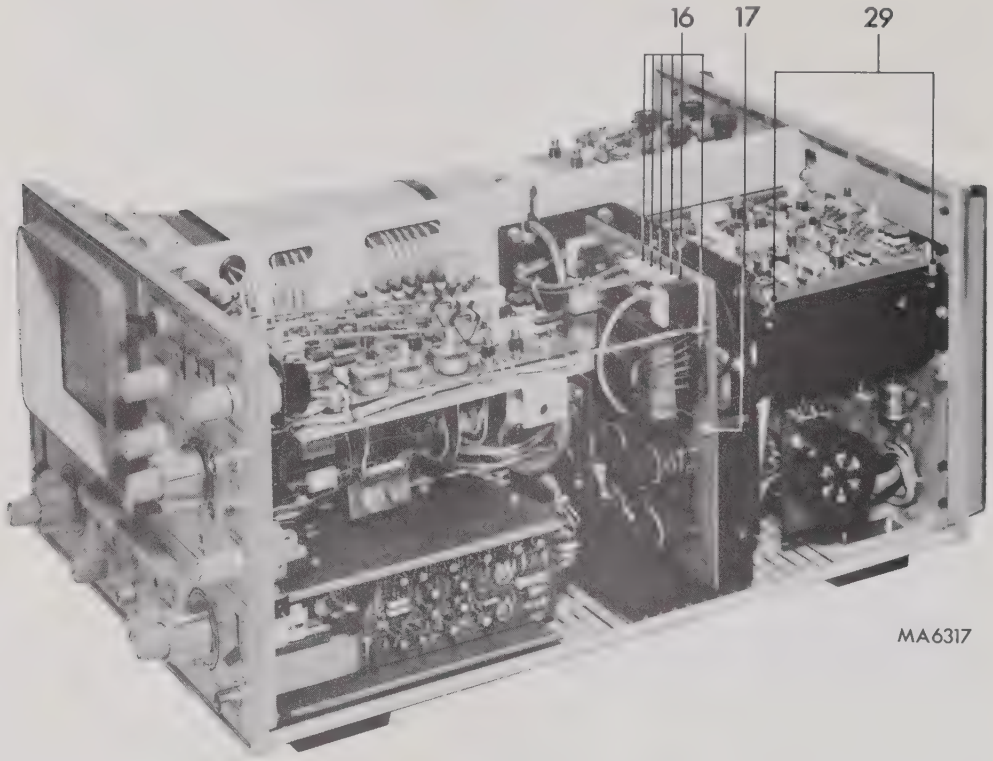


Fig. 40. Dismantling; view from the right

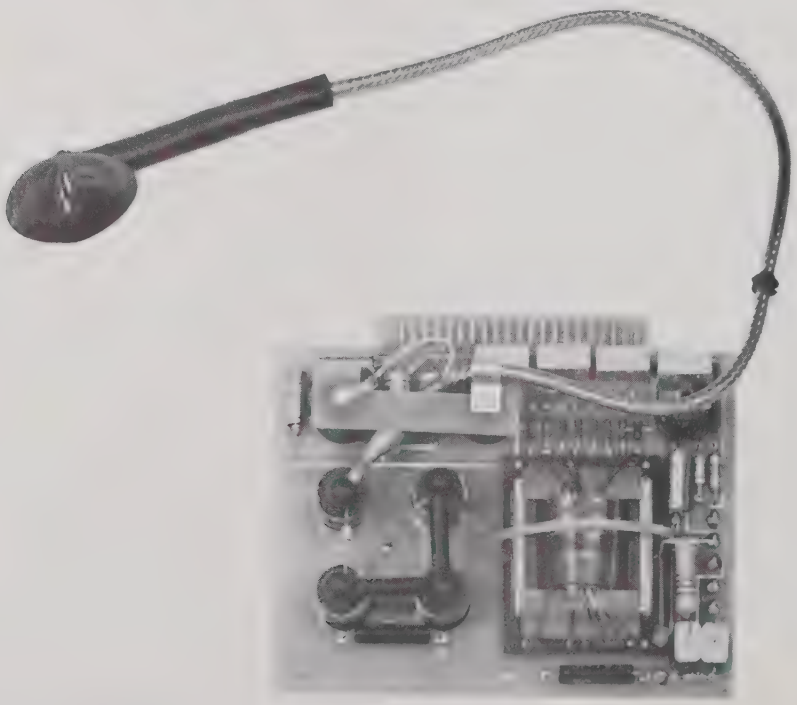


Fig. 41. Convertor unit 6 removed

K. REMOVING THE DELAY-LINE UNIT 11 (Figs. 32 & 42)

– Unplug connectors 3 on the pre-amplifier boards.
– Unscrew brackets 18.
– Unsolder the wiring (points 19).
– Remove the four screws 20.
– Remove the unit.

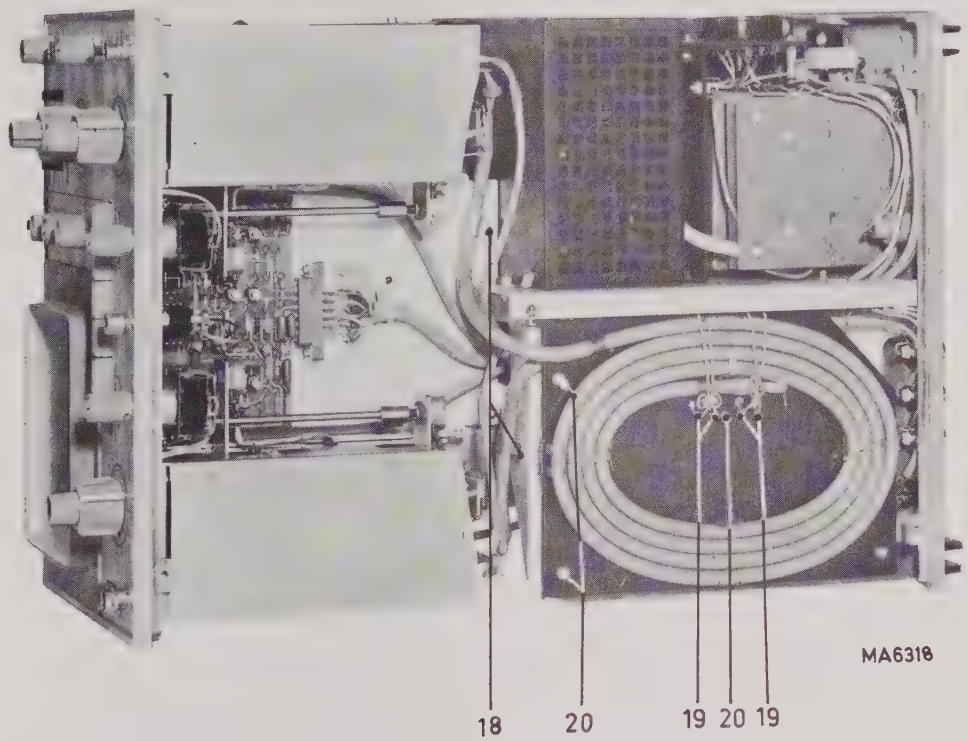


Fig. 42. Dismantling; bottom view

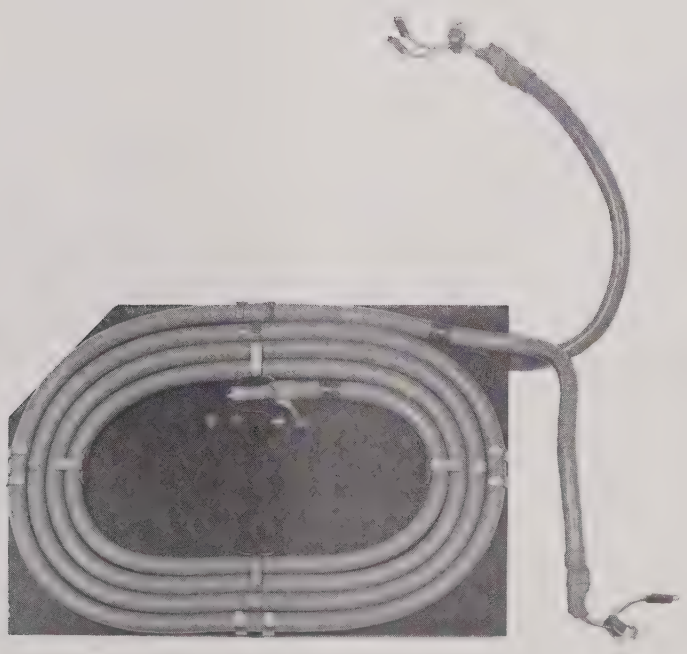


Fig. 43. Delay-line unit 11 removed

L. REMOVING SWITCH UNIT 5 (Fig. 44)

– Remove screw 21 and the two screws 22.
– Slacken screw 24 (with an Allen key) and remove shaft 23.
– Slide the pilot lamp off the bracket.
– Remove the unit.

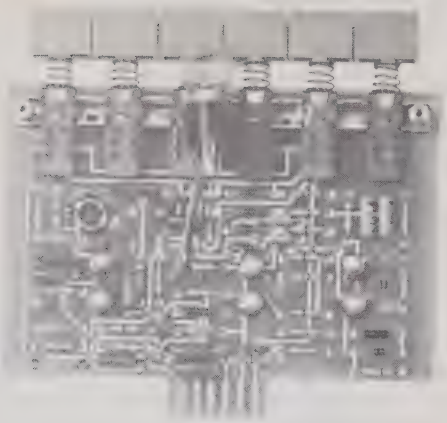


Fig. 45. Switch unit 5 removed

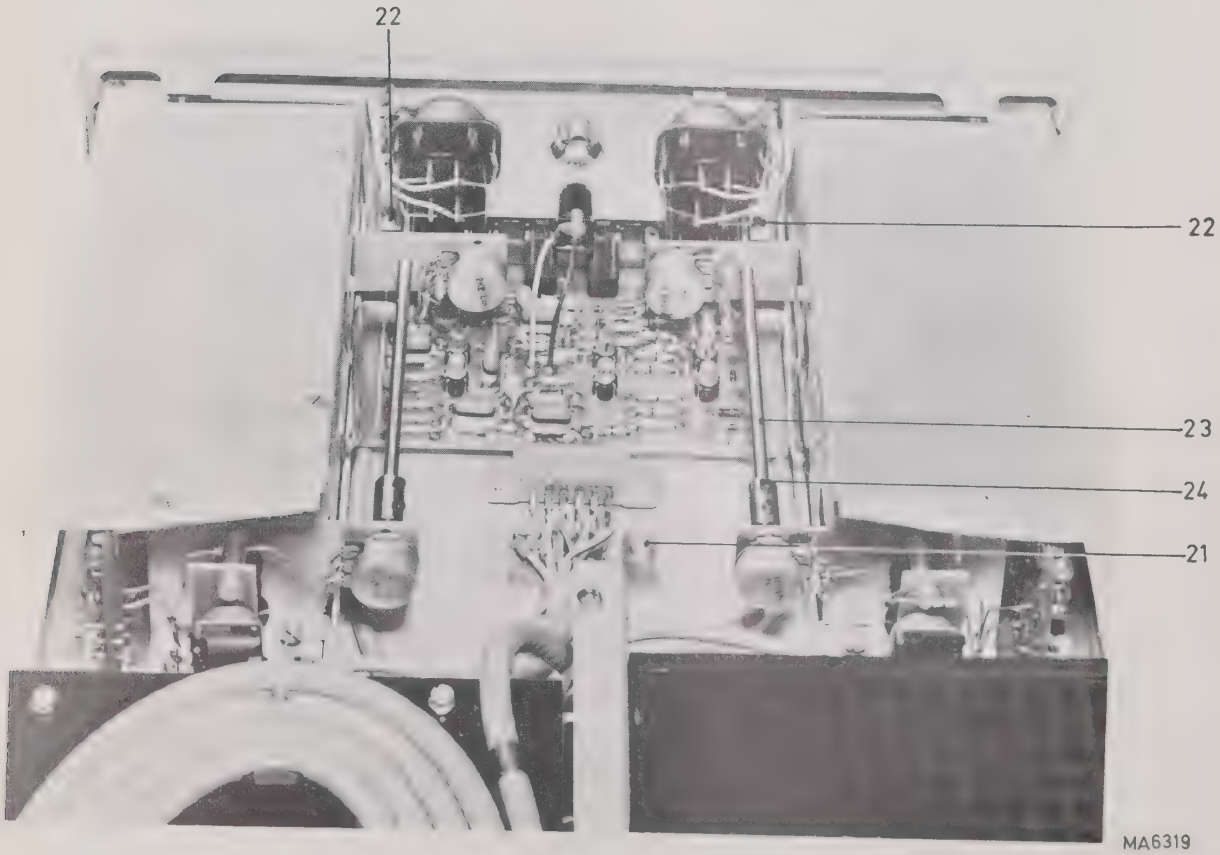


Fig. 44. Dismantling; bottom view (detail)

M. REMOVING MAINS TRANSFORMER UNIT 10 (Figs. 32 & 46)

– Remove the two screws 25 from rear lid 26.
– Unsolder the connection wires of the transformer.
– Remove screw 27 and the four screws 28.
– Remove the transformer.

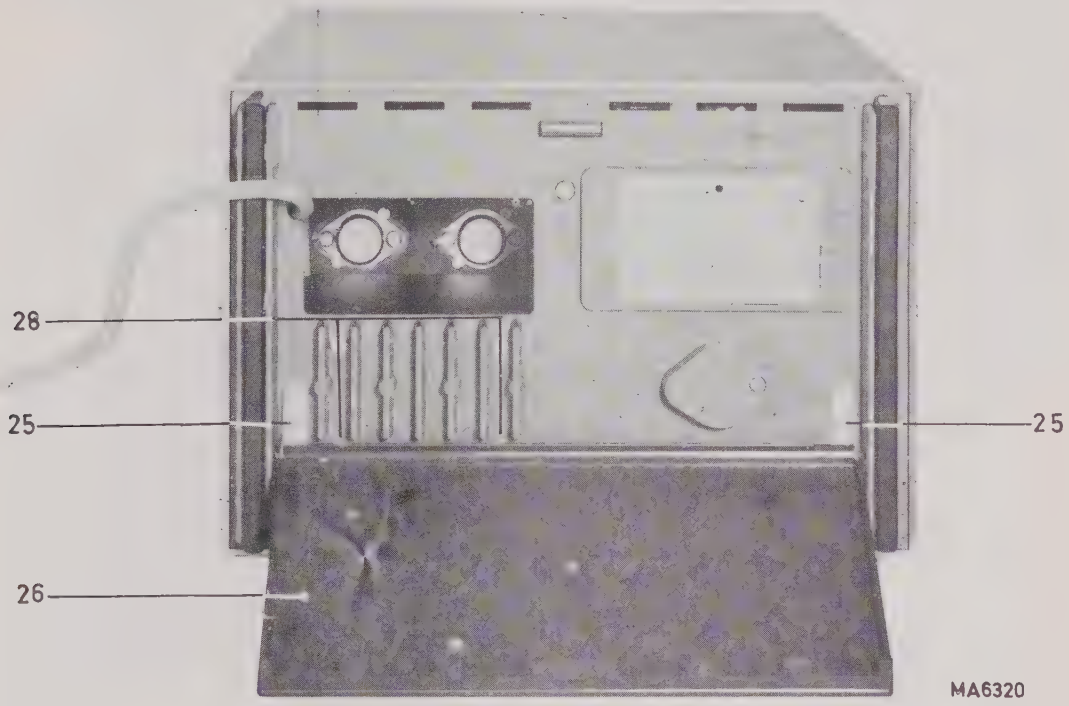


Fig. 46. Dismantling; rear view

N. REMOVING COMBINATION UNIT 8 (Fig. 40)

– Remove the two screws 29.
– Remove the unit.

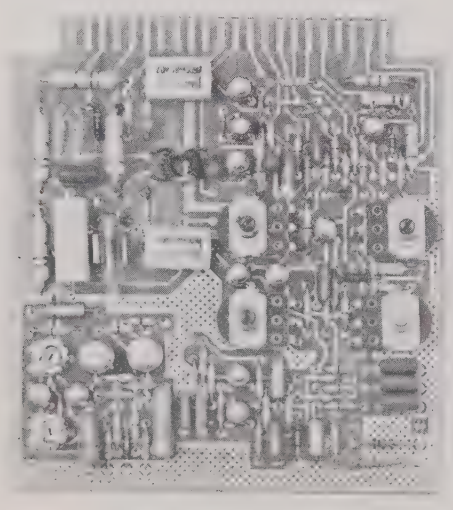


Fig. 47. Combination unit 8 removed

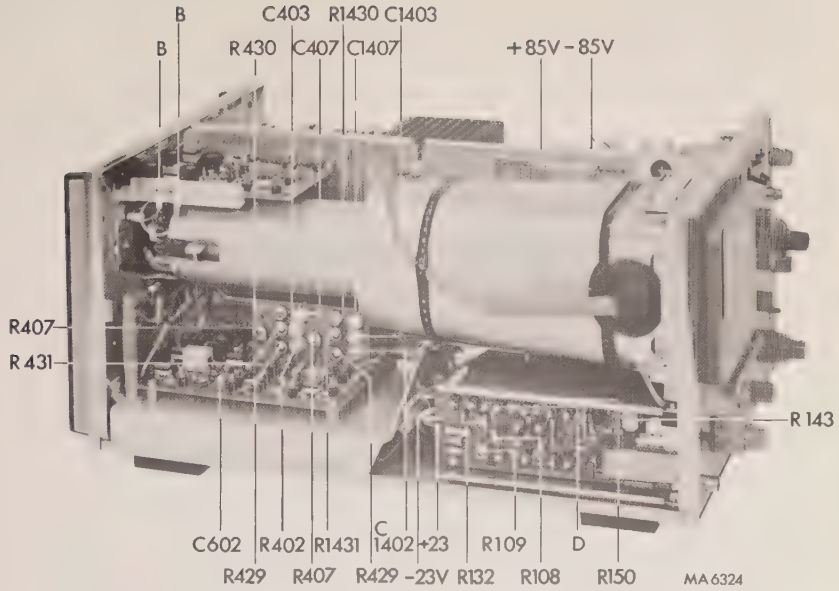


Fig. 49. Checking and adjusting; left-hand side view

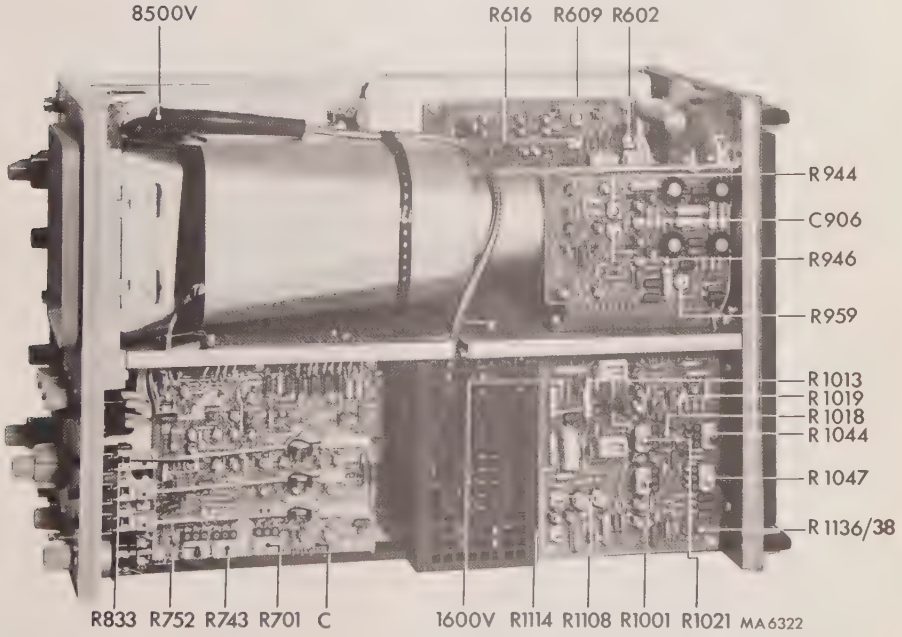


Fig. 50. Checking and adjusting; top view

O. REMOVING THE C.R.T. (Fig. 48)

- Remove the horizontal amplifier unit (see para. F).
- Remove bezel with graticule and contrast filter.
- Release the H.T. connection on the c.r.t. and discharge the connection point and the cable.
- Remove the c.r.t. base.
- Slacken the two screws 30.
- Unplug the two connectors 11.
- Slide the c.r.t. together with the mu-metal tube towards the front of the instrument.
- Slide the c.r.t. out of the mu-metal tube.

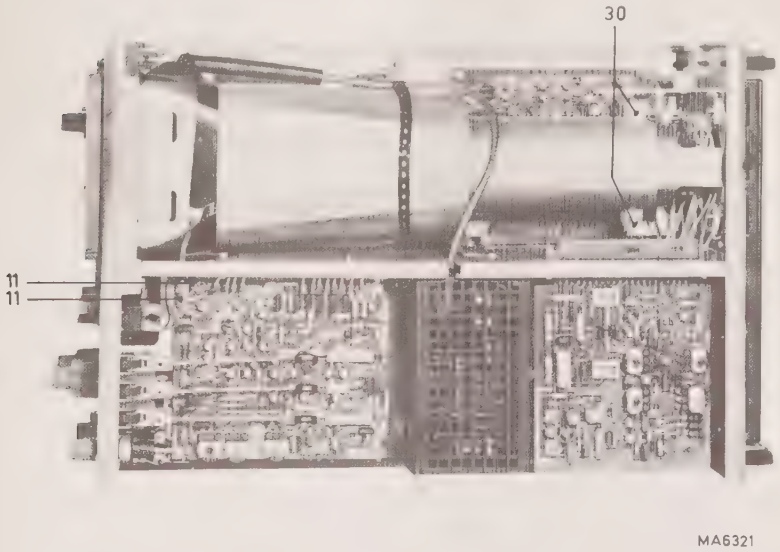


Fig. 48. Dismantling; top view

X. Checking and adjusting

A. GENERAL INFORMATION

All adjusting elements have been listed in the headings of the various sections.
The tolerances mentioned in the following text apply for newly adjusted instruments only. The values may differ from those given in chapter II. CHARACTERISTICS.

B. POWER SUPPLY

1. Mains current

- Set selector switch SK10 to position CHOPPED.
- Turn potentiometer ILLUM. R5 clockwise.
- Pull potentiometer LEVEL R1/SK5 to position AUTO.
- Check that the mains voltage selector has been adjusted to 220 V and connect the instrument to such a voltage (frequency 50 Hz).
- Switch in the oscilloscope.
- Check that the power consumption does not exceed 550 mA (measured with a moving-iron meter).

2. +23 V Power supply (R1108, R1114)

- Check that the +23 V (Fig. 49) voltage is accurate within 0.5 % at nominal mains voltage. If necessary readjust R1114 (Fig. 50).
- Display the ripple on the +23 V power supply with the aid of an oscilloscope.
- Adjust R1108 (Fig. 50) for minimum ripple.
- Vary the a.c. voltage to which the instrument is connected between 198 V and 242 V. Check that the +23 V voltage does not vary more than 1 %. The ripple voltage should not exceed 10 mV_{p-p}.
- Check the presence of the voltages −23 V, +85 V, −85 V, −1600 V and +8500 V, tolerance ±10 % (Figs. 49 & 50).

C. CATHODE-RAY TUBE CIRCUIT

C1. Unblanking (R1001)

- Pull potentiometer LEVEL R1/SK5 to position AUTO.
- Set TIME/cm SK6 to position 10 ms.
- Set selector switch SK10 to position Y_A.
- Adjust potentiometer INTENS. R2 so, that the time-base line is just visible.
- Check that the intensity of the time-base line is constant along its entire length. If necessary readjust potentiometer R1001 (Fig. 50).

C2. Deflection-plate potential

a. Vertical (R602)

- Set selector switch SK10 to position Y_A.
- Set switch Y_A - Y_B-EXT SK4 to position Y_A.
- Pull potentiometer LEVEL R1/SK5 to position AUTO.
- Set switch AC-0-DC SK9 to position DC.
- Set AMPL. SK12 to position 50 mV.
- Apply a square-wave voltage of 200 mV, repetition rate 100 kHz and with a rise time of $\leqslant$ 10 ns, to input socket Y_A BU3.
- Check that during shifting with potentiometer POSITION R14 the square-wave response does not change.
  If necessary readjust potentiometer R602 (Fig. 50).

b. Horizontal (R959)

- Set selector switch SK10 to position Y_A.
- Set switch Y_A - Y_B - EXT SK4 to position Y_A.
- Set switch AC-0-DC SK9 to position 0.
- Pull potentiometer LEVEL SK5 to position AUTO.
- Set potentiometer INTENS R2 for maximum intensity.
- Turn potentiometer POSITION R7 (in position x 1) fully clockwise and counterclockwise, and adjust potentiometer R959 (Fig. 50) so that there is just no bright not visible at the extremes of the time-base line.

C3. Focus and astigmatism (R1044, R1013)

- Set selector switch SK10 to position Y_A.
- Set switch Y_A - Y_B - EXT SK4 to position Y_A.
- Pull potentiometer LEVEL R1/SK5 to position AUTO.
- Set switch AC-0-DC SK9 to position AC.
- Apply a sine-wave signal at a frequency of 2 kHz to socket Y_A BU3. The trace height should be about 6 cm.

– Set TIME/cm SK6 to such a positon that a few cycles of the input signal are displayed.
– Adjust potentiometer FOCUS R3 and astigmatism potentiometer R1044 (Fig. 50) for a clear definition along the entire trace. If the control range of potentiometer FOCUS R3 is not sufficient, select a different value for resistor R1013 (Fig. 50).

C4. Trace rotation (R1048)

– Set selector switch SK10 to position Y_A.
– Set switch AC-0-DC SK9 to position 0.
– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Centre the time-base line by means of potentiometer POSITION R14.
– Check that the time-base line runs exactly in parallel with the horizontal lines of the graticule. If necessary, readjust trace-rotation potentiometer R1048 (Fig.51).

C5. Intensity (R1021, R1018, R1019)

– Switch the instrument off.
– Connect a current meter (30 μA) in series with the post-acceleration cable of the c.r.t.
– Switch in the instrument and wait 15 minutes.
– Set selector switch SK10 to position X-Y.
– Set AC-0-DC switches SK9 & 11 to position 0.
– Centre the display by means of potentiometers POSITION R14 & 15.
– Turn potentiometer INTENSITY R2 fully clockwise.
– Check that the current meter indicates 15 μA. If necessary readjust potentiometer R1021 (Fig. 50). If the control range of R1021 is not sufficient, select a different value for R1018 (Fig. 50).
– Turn potentiometer INTENSITY R2 to about 90° from its anti-clockwise stop. The trace should disappear.
If necessary select a different value for R1019 (Fig.50).
– Repeat both adjustments.

C6. Intensity modulation

– Set selector switch SK10 to position Y_A.
– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Check that the intensity of the time-base line is constant along its entire length.
– Set switch TIME/cm SK6 to position 1 μs.
– Set potentiometer TIME/cm R4 to position CAL.
– Pull potentiometer POSITION R7/SK8 to position MAGN. x 5. At the beginning of the time-base line, 0.5 cm at maximum may be dark.

C7. Distortion (R1047)

– Set selector switch SK10 to position X-Y.
– Set switches AC-0-DC SK9 & 11 to position AC.
– Apply a sine-wave signal with a frequency of about 50 kHz to socket Y_A BU3; trace height 7.5 cm.
– Apply a sine-wave signal with a frequency of about 50 Hz to socket Y_B BU5; trace width 9.5 cm.
– Adjust potentiometer R1047 (Fig. 50) so that the sides of the displayed oblong are as straight as possible.
– Check that no point of a display whose extreme points just touch the sides of an oblong of 9.5 x 7.5 cm lies within a concentric oblong of 9.28 x 7.36 cm.

D. PRE-AMPLIFIERS CHANNEL A AND CHANNEL B

The adjustments of the pre-amplifiers channel A and channel B are identical. The knobs, sockets and adjusting elements of channel B are shown in brackets after those of channel A.

D1. Balance and gate current [R109 (309), R108 (308), R150 (350), R143 (343)]

– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Set switch TIME/cm SK6 to position 1 ms.
– Set selecter switch SK10 to position Y_A (Y_B).
– Set switch AMPL. SK12 (SK13) to position 50 mV/cm.
– Set potentiometer POSITION R14 (R15) to the centre of its control range.
– Set switch AC-0-DC SK9 (SK11) to position 0.
– Adjust potentiometer R109, Fig. 49 (R309, Fig. 51) so that the trace does not move when potentiometer AMPL. R8 (R13) is rotated. If necessary select a different value for R108, Fig. 49 (R308, Fig. 51).
– Set switch SK12 (SK13) to position 1 mV/cm.
– Adjust potentiometer DC BAL. R10 (R11) so that the trace does not move when potentiometer AMPL. R8 (R13) is rotated. If necessary select a different value for R150, Fig. 49 (R350, Fig. 51).
– Adjust potentiometer R143, Fig. 49 (R343, Fig. 50) so that the trace does not move when switch AC-0-DC SK9 (SK11) is switched over from 0 to DC.
– Repeat the adjustments of this paragraph.

D2. Control amplifier [R132 (332)]

– Set switch LF-HF-DC SK2 to position DC.
– Set switch Y_A - Y_B - EXT SK4 to position Y_A (Y_B).
– Set switch AC-0-DC SK9 (SK11) to position DC.
– Apply a square-wave voltage with an amplitude of 300 mV and a repetition rate of 10 Hz to socket Y_A BU3 (Y_B BU5).
– Set switch AMPL. SK12 (SK13) to position 50 mV/cm.
– Set switch TIME/cm SK6 to such a position that a few cycles of the input signal are displayed.
– Adjust potentiometer LEVEL R1 for a stationary display.
– Adjust potentiometer R132, Fig. 49 (R332, Fig. 51) for a straight top of the square-wave.
– Check the top in positions 1,2,5,10 and 20 mV of switch AMPL.SK12 (SK13) at a trace height of 6 cm; the top errors should not exceed 1 %.

D3. Normal-Invert balance [(R1407 (407))]

– Set selector switch SK10 to position Y_A (Y_B).
– Set switch AMPL. SK12 (SK13) to position 50 mV/cm.
– Set switch AC-0-DC SK9 (SK11) to position 0.
– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Adjust potentiometer R1407, Fig. 49 (R407, Fig. 49) so that the trace does not jump when switch SK14 (SK15) is pulled to the INVERT position.

E. VERTICAL AND HORIZONTAL SENSITIVITY

NOTE: For sensitivity adjustments always stick to the following sequence: Channel B, X amplifier, Channel A.

E1. Channel B (R616)

– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Set switch TIME/cm SK6 to position 5 ms.
– Set switch AC-0-DC SK11 to position DC.
– Set switch AMPL. SK13 to position 200 mV/cm.
– Set switch LF-HF-DC SK2 to position LF.
– Set switch Y_A - Y_B - EXT SK4 to position Y_B.
– Set potentiometer AMPL. R13 to position CAL.
– Set selector switch SK10 to position Y_B.
– Interconnect sockets CAL. BU2 and Y_A BU5.
– Set potentiometer GAIN ADJ. R12 to the electrical centre of its control range.
– Adjust potentiometer R616, Fig. 50, for a trace height of 5 cm.
– Check that the control range of potentiometer AMPL. R13 is 1:2.6 to 1:3.5.

E2. X-Amplifier (R944)

– Set selector switch SK10 to position X-Y.
– Adjust potentiometer R944, Fig. 50, for a trace width of 5 cm.
– Check the time-base sweep speeds (section N).

E3. Channel A

– Set selector switch SK10 to position ADDED.
– Set switch AC-0-DC SK9 to position DC.
– Set switch AMPL. SK12 to position 200 mV/cm.
– Set potentiometer AMPL. R8 to position CAL.
– Apply the same input signal to sockets Y_A BU3 and Y_B BU5.
– Pull potentiometer POSITION R14/SK14 to position INVERT and make sure that potentiometer POSITION R15/SK15 is in the depressed position.
– Adjust potentiometer GAIN ADJ. R9 to obtain one straight line on the screen.
– Set selector switch SK10 to position Y_A.
– Check that the control range of potentiometer AMPL. R8 is 1:2.6 to 1:3.5.

F. INPUT ATTENUATOR

The adjustments of the input attenuators of channels A and B are identical. The knobs, sockets and adjusting elements of channel B are shown in brackets after those of channel A.

– Set selector switch SK10 to position Y_A(Y_B).
– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Set switch Y_A - Y_B - EXT SK4 to position Y_A (Y_B).
– Set switch AC-0-DC SK9 (SK11) to position DC.
– Set switch TIME/cm SK6 to position 50 μs.
– Set potentiometer AMPL. R8 (R13) to position CAL.
– Apply a square-wave voltage with a repetition rate of about 10 kHz and a rise time of 200 ns to socket Y_A BU3 (Y_B BU5). The amplitude of the input signal is indicated in the table below.
– According to the following table, adjust the attenuator so that just neither overshoot nor undershoot occurs.

AMPL. SK12 (SK13)	Input voltage	Adjust with (see Fig. 53)	Trace height
1 mV/cm	6 mV	C42 (C242)	6 cm ±2 %
2 mV/cm	12 mV		6 cm ±2 %
5 mV/cm	30 mV		6 cm ±2 %
10 mV/cm	60 mV	C38 (C238)	6 cm ±2 %
20 mV/cm	120 mV		6 cm ±2 %
50 mV/cm	300 mV		6 cm ±2 %
.1 V/cm	.6 V	C34 (C234)	6 cm ±2 %
.2 V/cm	1.2 V		6 cm ±2 %
.5 V/cm	3 V		6 cm ±2 %
1 V/cm	6 V	C33 (C233)	6 cm ±2 %
2 V/cm	12 V		6 cm ±2 %
5 V/cm	30 V		6 cm ±2 %
10 V/cm	60 V	C29 (C229)	6 cm ±2 %
20 V/cm	80 V		4 cm ±2 %

Maximum top errors 2 %

– Apply the above mentioned input voltages via a dummy measuring probe, consisting of a 1 MΩ resistor and a 15 pF capacitor, to input socket Y_A BU3 (Y_B BU5).
– According to the following table, adjust the attenuator so that just no overshoot occurs.

AMPL. SK12 (SK13)	Input signal on dummy probe	Adjust with (see Fig. 53)	Trace height
1 mV/cm	6 mV	C43 (C243)	3 cm ±3 %
2 mV/cm	12 mV		3 cm ±3 %
5 mV/cm	30 mV		3 cm ±3 %
10 mV/cm	60 mV	C39 (C239)	3 cm ±3 %
20 mV/cm	120 mV		3 cm ±3 %
50 mV/cm	300 mV		3 cm ±3 %
.1 V/cm	.6 V	C36 (C236)	3 cm ±3 %
.2 V/cm	1.2 V		3 cm ±3 %
.5 V/cm	3 V		3 cm ±3 %
1 V/cm	6 V	C32 (C232)	3 cm ±3 %
2 V/cm	12 V		3 cm ±3 %
5 V/cm	30 V		3 cm ±3 %
10 V/cm	60 V	C28 (C228)	3 cm ±3 %
20 V/cm	80 V		2 cm ±3 %

Maximum top errors 2 %

G. STEP RESPONSE OF THE VERTICAL AMPLIFIERS

The adjustments of the step responses of channels A and B are identical.
The adjusting elements are:

Fig. 49	Fig. 50	Fig. 56	Fig. 58	Fig. 58A	Fig. 59
R429 (R1429)	R609	R280	C409	R432 (R1432)	R80
R430 (R1430)		C249		R435 (R1435)	C49
R431 (R1431)		C252		C404 (C1404)	C52
C402 (C1402)		R296		C406 (C1406)	R96
C403 (C1403)		C264			C64
C407 (C1407)					
C602					

The knobs, sockets and adjusting elements of channel B are shown in brackets after those of channel A.

- Set switch AC-0-DC SK9 (SK11) to position DC.
- Set switch AMPL. SK12 (SK13) to position 50 mV/cm.
- Set potentiometer AMPL. R8 (R13) to position CAL.
- Set selector switch SK10 to position Y_A (Y_B).
- Pull potentiometer LEVEL R1/SK5 to position AUTO.
- Set switch LF-HF-DC (SK2) to position DC.
- Set switch Y_A - Y_B - EXT (SK4) to position Y_A (Y_B).
- Apply a square-wave voltage of 300 mV with a repetition rate of 100 kHz and a rise time $\leqslant$ 1 ns to socket Y_A BU3 (Y_B BU5).
- Adjust the square-wave response so that the top is as straight as possible, the rise time minimum and the ringing as small as possible (see Fig. 42).

ATTENTION: Potentiometer R609 and capacitor C602 affect the square-wave response of both channel A and channel B.

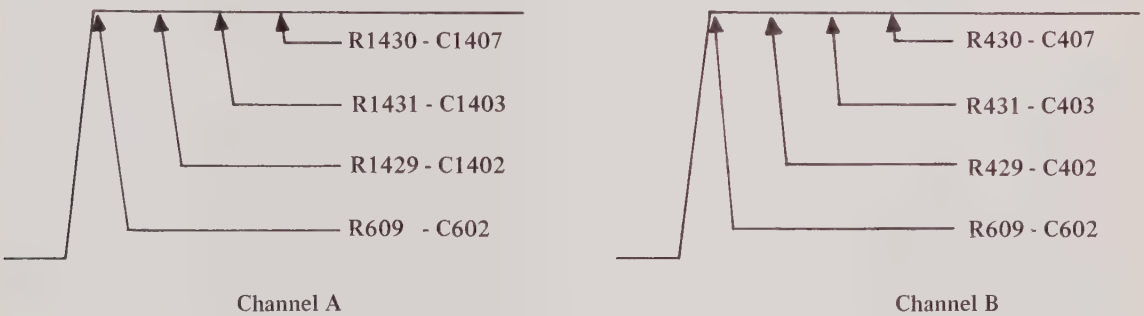


Fig. 52. Square-wave response

- Check that the square-wave response does not change when potentiometer POSITION R14/SK14 (R15/SK15) is switched from the normal position to the INVERT position. The maximum difference in top error may by 2 %.
- Reduce the repetition rate to 50 kHz and check that the top of the pulse is straight. If necessary correct with network C1406 - R1432 (C406 - R432).
- Reduce the repetition rate to 20 kHz and check that the top of the pulse is straight. If necessary correct with network C1404 - R1435 (C404 - R435).
- Increase the repetition rate to 100 kHz.
- Set switch AC-0-DC SK11 to position 0.
- Check that the difference in top errors in positions Y_A and ADDED of selector switch SK10 does not exceed 2 %. If necessary select a different value for capacitor C409 and readjust the square-wave response.
- Check the square-wave response in positions 20, 10, 5, 2 and 1 mV/cm of switch AMPL. SK12 (SK13) at an amplitude of 6 cm. The overshoot or undershoot should not exceed 2 %.
- In position 10 mV/cm of switch AMPL. SK12 (SK13) there is the possibility of correction by selection of a different value for capacitor C49 (C249) and resistor R44 (R244).
- In positions 5 and 2 mV/cm, correction is possible by adapting correction network R96-C52 (R296-C252).
- In position 1 mV/cm, correction is possible by adapting network C64-R80 (C264-R280).

H. BANDWIDTH VERTICAL AMPLIFIERS

– Set switch AMPL. SK12 (SK13) to position 1 mV/cm.
– Check the bandwidth at a trace height of 8 cm according to the following table:

FREQUENCY	INPUT SIGNAL	TRACE HEIGHT
100 kHz	40 mV	8 cm
25 MHz	40 mV	$\geqslant$ 5.6 cm

I. H.F. DEFLECTION

– Set selector switch SK10 to position Y_A (Y_B).
– Set switch AMPL. SK12 (SK13) to position 50 mV/cm.
– Set potentiometer AMPL. R8 (R13) to position CAL.
– Set switch LF-HF-DC SK2 to position DC.
– Set switch Y_A - Y_B - EXT SK4 to position Y_A.
– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Set switch AC-0-DC SK9 (SK11) to position AC.
– Apply a sine-wave signal of 1.2 V and a frequency of 10 MHz to input socket Y_A BU3 (Y_B BU5).
– Check that the peaks of the signals can be displayed undistortedly within the graticule, both in depressed and pulled positions of switch INVERT SK14 (SK15).

J. REFJECTION FACTOR

– Set switches AC-0-DC SK9 & 11 to position DC.
– Set switches AMPL. SK12 & 13 to position 50 mV/cm.
– Set selector switch SK10 to position ADDED.
– Depress switch INVERT SK14 to the normal position.
– Pull switch INVERT SK15 to position INVERT.
– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Set switch LF-HF-DC SK2 to position DC.
– Set switch Y_A - Y_B -EXT SK4 to position Y_A or Y_B.
– Apply equal sine-wave signals in the same phase to input sockets Y_A BU3 and Y_B BU5.
– Measure the rejection according to the following table. Always adjust for minimum trace height with potentiometers AMPL. R8 and R13, starting from their CAL. positions.

FREQUENCY	REJECTION FACTOR	MAX. TRACE HEIGHT
50 Hz	100x	2.5 mm
1 MHz	100x	2.5 mm

K. SIGNAL DELAY EQUALITY

(This check is only necessary if a new delay line has been fitted).
Set switch LF-HF-DC SK2 to position HF.
– Set switch +/ - SK3 to position +.
– Set switch Y_A - Y_B -EXT SK4 to position Y_A.
– Set switches AMPL. SK12 & 13 to position 50 mV/cm.
– Set potentiometers AMPL. R8 & 13 to position CAL.
– Set TIME/cm SK6 to position .1 μs.
– Set potentiometer TIME/cm R4 to position CAL.
– Pull switch MAGN. SK8 to position x 5.
– Set selector switch SK10 to position CHOPPED.
– Set switches AC-0-DC SK9 & 11 to position AC.
– Apply a 300 mV pulse with a rise time of $\leqslant$ 3 ns to input socket Y_A BU3 and Y_B BU5.
– Check that there is no difference in delay time between the amplifiers of channels A and B (1 ns is acceptable). If necessary reduce the length of one of the delay lines.

L. X-Y ADJUSTMENT (C906, R946)

– Depress switches INVERT SK14 & 15.
– Set selector switch SK10 to position X-Y.
– Set switches AC-0-DC SK9 & 11 to position AC.
– Set switches AMPL. SK12 & 13 to position 50 mV/cm.
– Set potentiometers AMPL. R8 and R13 to position CAL.
– Apply equal sine-wave signals of 300 mV in phase to input sockets Y_A BU3 and Y_B BU5.
– Check that at a signal frequency of 2 kHz a line under an angle of 45° with respect to the horizontal graticule lines is displayed. If not, readjust the sensitivity according to section E.
– Increase the signal frequency to 5 MHz and adjust the angle between the displayed line and the horizontal graticule lines to 45° by means of trimmer C906, Fig. 50.
– Adjust potentiometer R946, Fig. 50 for one straight line under an angle of 45°.
– Check at various frequencies between 2 kHz and 5 MHz that there are no phase errors. If necessary repeat the previous adjustments.
– Pull potentiometer INVERT R14/SK14 to position INVERT.
– Check that the phase error at frequencies up to 5 MHz does not exceed ±1°.

Bandwidth in position X-Y of selector switch SK10:
– Set switch AC-0-DC SK9 to position 0.
– Check the frequency response at a trace width of 6 cm:

FREQUENCY	INPUT SIGNAL	TRACE HEIGHT
2 kHz	300 mV	6 cm
5 MHz	300 mV	$\geqslant$ 4.2 cm

– Check section N when C906 or R946 has been readjusted.

M. TIME-BASE GENERATOR

M1. Stability

- Set switch LF-HF-DC SK2 to position LF.
- Set potentiometers POSITION R7 & 14 to the centres of their control ranges.
- Set selector switch SK10 to position Y_A.
- Set switch TIME/cm SK6 to 1 ms.
- Turn potentiometer LEVEL R1 fully clockwise (switch SK5 depressed).
- Adjust potentiometer STAB. R6 so that the time-base line is just not visible (do not adjust this too critically).
- Pull potentiometer LEVEL to position AUTO. There should be a time-base line visible.

M2. Trigger level (R701)

- Set switch LF-HF-DC SK2 to position DC.
- Set switches AC-0-DC SK9 & 11 to position 0.
- Set switches AMPL. SK12 & 13 to position 50 mV/cm.
- Check, and readjust if necessary, the d.c. balance.
- Set switch Y_A - Y_B -EXT SK4 to position Y_A.
- Adjust potentiometer R701 (Fig. 50) so that the voltage on point C (emitter of transistor TS703) is 0 V ±300 mV.
- Set switch Y_A - Y_B - EXT SK4 to position Y_B.
- Check that the voltage on point C is still 0 V ±300 mV.

M3. Trigger adjustment (R743, R752)

- Set switch LF-HF-DC SK2 to position LF.
- Depress potentiometer LEVEL R1/SK5 to the level position .
- Set switch +/-SK3 to position +.
- Set switch Y_A - Y_B - EXT SK4 to position Y_A.
- Set switch TIME/cm SK6 to position 1 ms.
- Set switches AC-0-DC SK9 & 11 to position AC.
- Set switches AMPL. SK12 & 13 to 50 mV/cm.
- Set potentiometers AMPL. R8 & 13 to position CAL.
- Depress potentiometers POSITION R14/SK14 & R15/SK15 to their normal positions.
- Set selector switch SK10 to position Y_A.
- Apply a sine-wave signal of 300 mV and a frequency of 2 kHz to input socket Y_A BU3.
- Adjust potentiometer LEVEL R1 for a stationary display.
- Without touching the level adjustment, adjust potentiometer R743, Fig. 51, so that the triggering point does not move when switch +/– SK3 is set from + to –.
- Reduce the input voltage until the trace height is 0.3 cm (do not use the AMPL. potentiometer to this end).
- Adjust potentiometer LEVEL for a stationary trace.
- Check that the triggering is not disturbed when switch +/– SK3 is set from + to –. If necessary readjust R743.
- Increase the input voltage until the trace height is about 8 cm.
- Check that triggering occurs on the positive - going edge when switch +/– SK3 occupies position +, and on the negative-going edge in position –.
- Check that the trigger point is shifted upwards when potentiometer LEVEL R1 is turned clockwise, and vice-versa.
- Pull potentiometer LEVEL R1/SK5 to position AUTO and turn it to the centre of its control range.
- Adjust potentiometer R752, Fig. 51, so that the time-base starts at the 0 level of the sine-wave.
- Check that the trigger point is still at the 0 level of the sine-wave when its amplitude has been reduced. If necessary readjust potentiometer R752.
- Check that the trigger point does not move when switch +/– SK3 is set from + to –.
- Repeat these adjustments until the amplitude of the input signal is as small as possible.
- Increase the input voltage to 800 mV.
- Depress potentiometer LEVEL R1/SK5 to the level position.
- Check that the time-base cuts out when potentiometer LEVEL R1 is turned fully clockwise and anti-clockwise.
- Pull potentiometer LEVEL R1/SK5 to position AUTO.
- Check that the trigger point can be shifted over approximately 3 cm with potentiometer LEVEL R1.
- Set switch LF-HF-DC SK2 to position DC.
- Set switch Y_A - Y_B - EXT SK4 to position EXT.
- Apply a sine-wave signal of 10 V, frequency about 2 kHz to socket TRIGG. BU1.
- Check that the time-base generator cuts out when potentiometer LEVEL R1 is turned fully clockwise and anti-clockwise.

M4. Trigger sensitivity

- Set switches AC-0-DC SK9 & 11 to position DC.
- Set potentiometers AMPL. R8 & 13 to position CAL.
- Set potentiometer LEVEL R1 to obtain triggering.
- Set TIME/cm SK6 so that a reasonable number of cycles is displayed.
- Check the trigger sensitivity according to the following table in both position + and position – of switch +/– SK3.

INPUT SIGNAL ON	SELECTOR SK10 TO	FREQUENCY (SINE-WAVE)	LF-HF-DC SK2 TO	Y_A-Y_B-EXT SK4 TO	LEVEL R1/SK5 TO	TRIGGERING AT
Y_A BU3	Y_A	10 Hz	LF	Y_A	AUTO	0.4 cm
		10 Hz			LEVEL	0.4 cm
		10 kHz				0.4 cm
		1 MHz				4 cm no trigg.
		50 Hz	HF			4 cm no trigg.
		5 MHz				0.4 cm
		25 MHz				2 cm
		1 Hz	DC			0.4 cm
		25 MHz				2 cm
Y_B BU5	Y_B	10 kHz	DC	Y_B	LEVEL	0.4 cm
		25 MHz				2 cm
TRIGG. BU1		1 Hz		EXT		400 mV
		10 kHz				400 mV
		25 MHz				800 mV

N. TIME COEFFICIENTS (R833, C823, C826)

– Check sections E. SENSITIVITY and L. X-Y ADJUSTMENT.
– Set switch HF-LF-DC SK2 to position HF.
– Set switch +/– SK3 to position +.
Set switch Y_A - Y_B - EXT SK4 to position Y_A.
– Set selector switch SK10 to position Y_A.
– Set potentiometer TIME/cm R4 to position CAL.
– Depress potentiometer MAGN. R7/SK8 to position x1.
– Set TIME/cm SK6 to position 1 ms.

Apply a time-marker voltage with a repetition time of 1 ms to socket Y_A BU3.
– Adjust potentiometer R833, Fig. 50, so that the 8 centre periods have a total width of 8 cm.
– Set switch TIME/cm SK6 to position 2 μs.
– Change the repetition time of the input signal to 2 μs.
Adjust trimmer capacitor C826, Fig. 51 so that the 8 centre periods have a total width of 8 cm.
Set TIME/cm SK6 to position .2 μs.
– Change the repetition time of the input signal to .2 μs.
– Adjust trimmer capacitor C823, Fig. 51 so that the 8 centre periods have a total width of 8 cm.
– Check that in the other positions of switch TIME/cm SK6 the 8 centre periods have a total width of 8 cm ±2 %.
Check that the length of the time-base line is 10.5 to 11.5 cm in all positions of switch TIME/cm SK6.

Set TIME/cm SK6 to position 1 ms.
Check that the control range of potentiometer TIME/cm R4 is 1:2.6 to 1:5.

Set TIME/cm SK6 to position 1 ms.
– Set potentiometer TIME/cm R4 to position CAL.
– Pull switch MAGN. SK8 to position x5.
– Change the repetition time of the input signal to 1 ms.
– Shift every cycle on the screen by means of potentiometer POSITION R7 and check that each cycle has a width of 5 cm ±1.5 % (do not take the first and last period into account).
– Check that with potentiometer POSITION R7 the beginning and the end of the time-base line can be displayed within the graticule.

O. DOUBLE TRACES AND JITTER

– Check that the trace is not doubled when the trace height and/or the frequency is varied and potentiometer LEVEL R1 is set for triggered display.
– Check that the time jitter does not exceed 10 ns.

P. MAINS VOLTAGE FLUCTUATIONS

– Vary the mains voltage + and –10 % with respect to the nominal mains voltage as indicated by the voltage adapter.
– Check that the vertical and horizontal deflection are not affected and that the brightness does not change.

Q. NOISE, CONVERTER INTERFERENCE, INSTABILITY AND DRIFT
THESE MEASUREMENTS SHOULD BE MADE WITH THE CABINET PLATES FITTED.

Set switches AMPL. SK12 & 13 to position 1 mV cm.
– Set potentiometers AMPL. R8 & 13 to position CAL.
– Set switches AC-0-DC SK9 & 11 to position AC.

– Set the other controls for convenient reading.
– Acceptable values:

noise	: 0.2 cm
converter interference	: 0.1 cm
instability	: 0.2 cm
drift	: 1 cm at maximum, after a warming-up period of a quarter of an hour and at a constant ambient temperature.

R. CROSS TALK

The following procedure applies to the checking of the effect from channel A on channel B. The controls and sockets involved in the procedure for checking the effect from channel B on channel A are shown in brackets.

– Set switch LF-HF-DC SK2 to position DC.
– Set switch Y_A - Y_B - EXT SK4 to position Y_A (Y_B).
– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Set switches AC-0-DC SK9 & 11 to position DC.
– Set selector switch SK10 to position CHOPPED.
– Apply a sine-wave voltage at a frequency of 25 MHz and an amplitude to obtain a trace height of 6 cm to input socket Y_A BU3 (Y_B BU5).
– Set switch AMPL. SK13 (SK12) to position 1 mV/cm.
– Set potentiometer AMPL. R13 (R8) to position CAL.
– Check that the cross talk does not exceed 0.3 cm.
– Decrease the frequency of the input signal to 10 MHz and increase the amplitude to an equivalent of 24 cm.
– Check that the cross talk does not exceed 0.3 cm.
– Apply a square-wave voltage with a repetition rate of 10 Hz and an amplitude equivalent to 24 cm to input socket Y_A BU3 (Y_B BU5).
– Check that the cross talk does not exceed 0.3 cm.

S. BRIGHTNESS MODULATION (R1001)

– Pull potentiometer LEVEL R1/SK5 to position AUTO.
– Set TIME/cm SK6 to position 10 ms.
– Depress switch MAGN. SK8 to x1 position.
– Adjust potentiometer INTENS. R2 for the desired brightness.
– Check that the time-base line is equally bright over the whole length (no thickenings). If necessary correct with potentiometer R1001, Fig. 50.
– Check that the time-base line is equally bright over the whole length (no thickenings) in all other positions of switch TIME/cm SK6.
– Set switch TIME/cm SK6 to position .1 μs.
– Set potentiometer TIME/cm R4 to position CAL.
– Pull switch MAGN. SK8 to position x5.
– Check that of the whole time-base line no more than 0.5 cm is dark at a normal brightness of the trace.

T. Z-MODULATION

– Apply a negative-going square-wave voltage of 5 V to socket Z MOD. BU6.
– Apply a signal which is synchronous with the former square-wave voltage to input socket Y_A BU3.
– Set switch AC-0-DC SK9 to position AC.
– Set selector switch SK10 to position Y_A.
– Set switch Y_A - Y_B - EXT SK4 to position Y_A.
– Set switch LF-HF-DC SK2 to position DC.
– Pull potentiometer LEVEL R1 to position AUTO.
– Check that at a pulse repetition rate of about 100 Hz and about 500 kHz, the trace is dark during the negative pulse, in positions 5 ms and 1 μs of switch TIME/cm SK6.

U. OUTPUT SOCKETS

U1. Calibration voltage on socket CAL. 1 V BU2 (R1136, R1138)

– Measure the voltage on socket CAL. 1 V BU2 with the aid of an accurate peak-voltmeter. This voltage should be 1 V ±0.7 %. If necessary select different values for resistors R1136 and R1138 (Fig. 50).
– Check that the pulse repetition rate is approximately 2 kHz.

U2. Vertical output voltage on socket Y OUT BU7

– Set selector switch SK10 to position Y_A.
– Set switch AMPL. SK12 to position 50 mV/cm.
– Set potentiometer AMPL. R8 to position CAL.
– Set switch AC-0-DC SK9 to position AC.
– Apply a sine-wave voltage of 300 mV and a frequency of 2 kHz to input socket Y_A BU3.
– Check that the signal voltage on socket Y OUT BU7 is approximately 1.5 V.

U3. Time-base voltage on socket TIME-BASE OUT BU6

– Check that there is a positive-going sawtooth of 6 V ±1 V available on socket TIME-BASE OUT BU6.
– Check that the d.c. level of the sawtooth voltage is 0 V ±1 V.

XI. Information for assistence in fault finding

A. VOLTAGE LEVELS AND WAVE FORMS

The d.c. levels and the wave forms on the most important points of the circuits have been indicated on the circuit diagram. These values may, however, slightly differ per instrument.

The measurements have been made under the following conditions:

- Mode selector SK10 in position Y_A.
  Switch Y_A - Y_B - EXT SK4 in position Y_A.
- Switch LEVEL SK5 to position AUTO.
  Potentiometer TIME/cm R4 in position CAL.
  Switch TIME/cm SK6 in position 1 ms.
- Potentiometers POSITION R14 & 15 in centre position.
- Switches AC-0-DC SK9 & 11 to position 0.

NOTE: For measurements on the horizontal amplifier, set switch SK5 of the LEVEL potentiometer to the level position (time-base inoperative). Further set potentiometer POSITION R7 so that the potentials on both horizontal-deflection plates are equal.

B. POSSIBLE FAULTS

B1. There is no light on the c.r.t.

Check the supply voltages +23 V, −23 V, +85 V, -1600 V and +8500 V.

Note: The −1600 V is present when neon tube B1002 on circuit board 8 lights up.

Set mode selector SK10 to position XY.
Turn potentiometer INTENS R2 fully clockwise.
Set potentiometers POSITION R14 & 15 to the centre position.
Set switches AC-0-DC SK9 & 11 to position 0.
If there is light now, the time-base generator does not work.

If there is no light, check the potentials of the horizontal- and vertical-deflection plates. If these potentials are about 0 V, the fault is in the blanking circuit, or the c.r.t. is faulty.

- Check the emitter voltage of transistor TS1006.
  Check the emitter voltage of transistor TS1004.
- Check oscillator TS1001 & 1002.

B2. There is only trace B visible

- Pull switch LEVEL SK5 to position AUTO.
- Set mode selector SK10 to position Y_A.
- Set potentiometer POSITION R14 to its centre position.
- Set switch AMPL. SK12 to position 50 mV/cm.
- Set switch AC-0-DC SK9 to position 0.
- Measure the voltage on the emitter of transistor TS39 (test point D, Fig. 49). If this voltage is 0 V and the voltage on the delay line is 0 V, then the vertical intermediate amplifier is faulty.
- If the voltage on the emitter of transistor TS39 does not equal 0 V, the pre-amplifier is faulty.
- Connect junction R48-R51-R49 in the gate circuit of f.e.t. TS26-2 to earth. If the emitter voltage of TS39 is then about 0 V (±200 mV), the drift-control amplifier is faulty.
- If the voltage is not 0 V, the fault is in the vertical amplifier. Check the potentials of the various points in the amplifier.

B3. There is only trace A visible

- Pull switch LEVEL SK5 to position AUTO.
- Set mode selector SK10 to position Y_B.
- Set potentiometer POSITION R15 to its centre position.
- Set switch AMPL. SK13 to position 50 mV/cm.
  Set switch AC-0-DC SK11 to position 0.
- Measure the voltage on the emitter of transistor TS239 (test point E, Fig. 51). If this voltage is 0 V and the voltage on the delay line is 0 V, then the vertical intermediate amplifier is faulty.
- If the voltage on the emitter of transistor TS239 does not equal 0 V, the pre-amplifier is faulty.
- Connect junction R248-R251-R249 in the gate circuit of f.e.t. TS226-2 to earth. If the emitter voltage of TS239 is then about 0 V (±200 mV), the drift-control amplifier is faulty.
  If the voltage is not 0 V, the fault is in the vertical amplifier. Check the potentials of the various points in the amplifier.

B4. Time base does not work

Turn potentiometer INTENS R2 clockwise.
Set AC-0-DC SK11 to position 0.

- Set potentiometers POSITION R7 & R15 to the centre position.
- Set mode selector SK10 to position Y_B.
- Set switch Y_A - Y_B - EXT SK4 to position Y_B.
- Pull the switch of potentiometer LEVEL R1 to AUTO.
- If the time-base generator works now, the trigger circuit is faulty:
  Check the stability setting and the potentials of the various points in the trigger circuit.
- If the time-base generator does not work yet, connect the collector of transistor TS804 to earth and check that the potentials of the various points in the time-base generator meet the values stated in the circuit diagram for the starting point of the time-base sweep.

C. NOTES

In case of a defect it is always possible to apply to the world wide PHILIPS Service Organisation.
When the instrument is to be sent to a PHILIPS Service workshop for repair, the following points should be observed:

- Attach a label with your name and address to the instrument.
- Give a complete description of the faults found.
- Use the original packing or, if this is no longer available, carefully pack the instrument in a wooden crate or box.
- Send the instrument to the address obtained after consultation with the local PHILIPS Organisation.

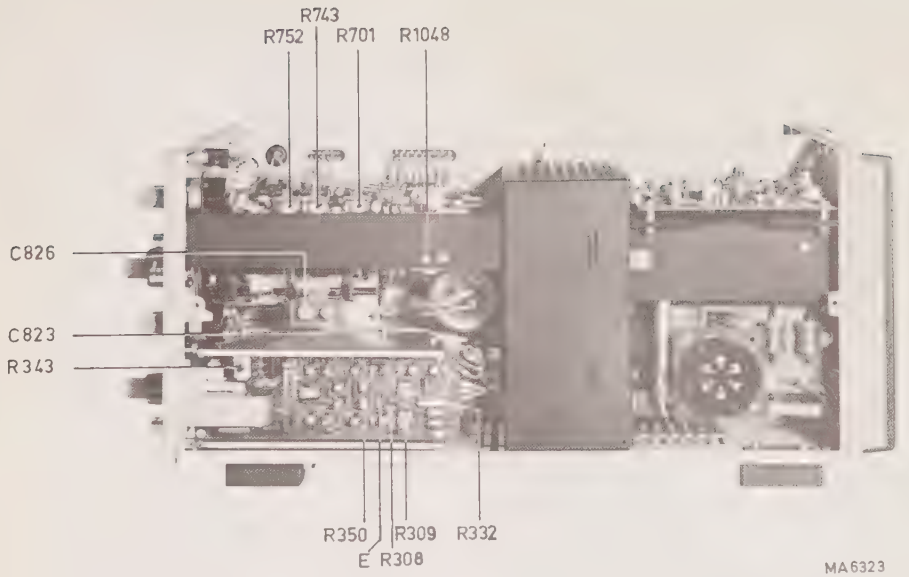


Fig. 51. Checking and adjusting; right-hand side view

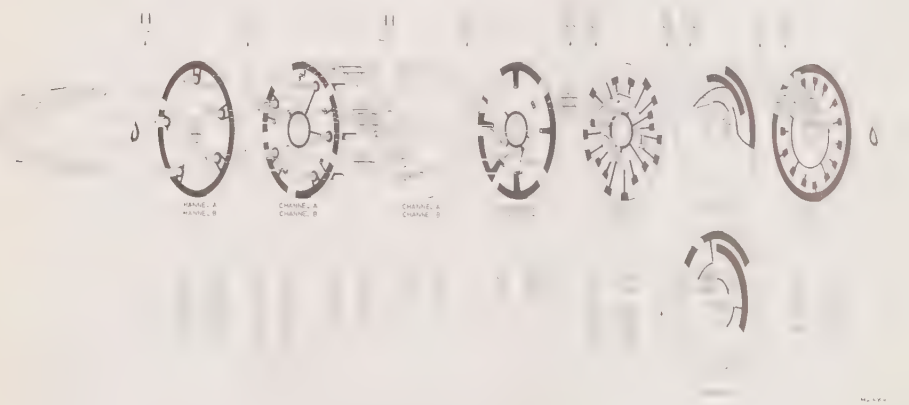


Fig. 53. Attenuator switch

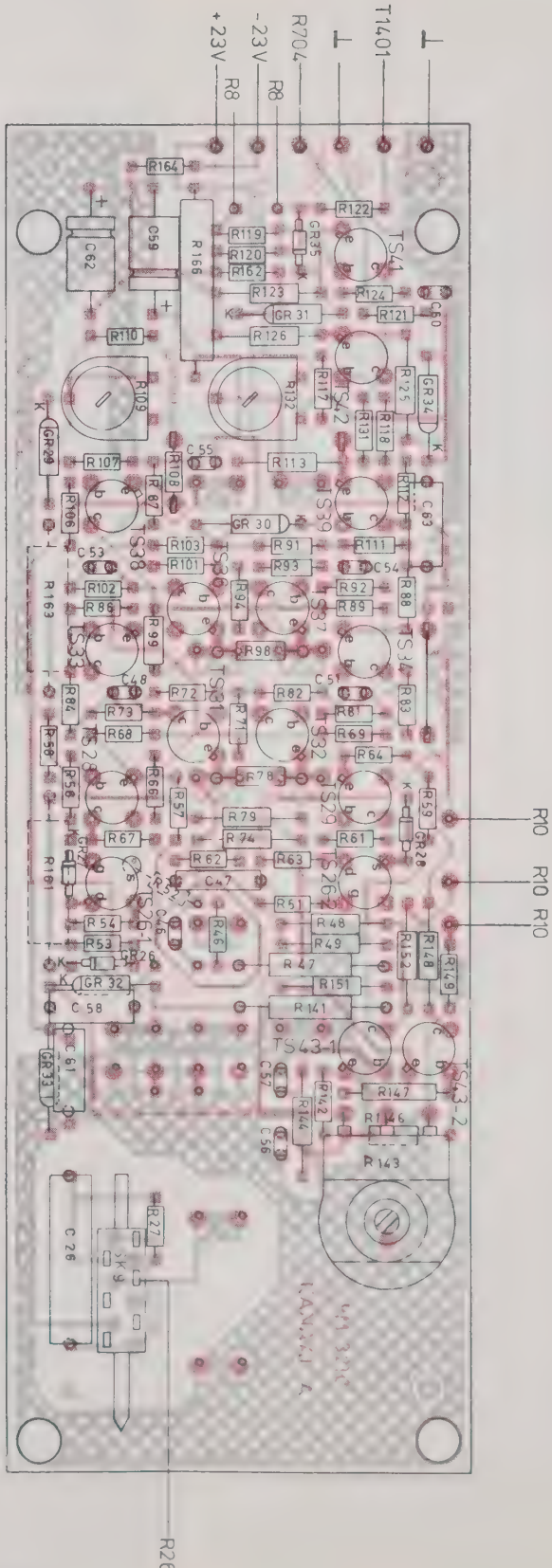


Fig. 54. Unit 1. Channel A vertical pre-amplifier

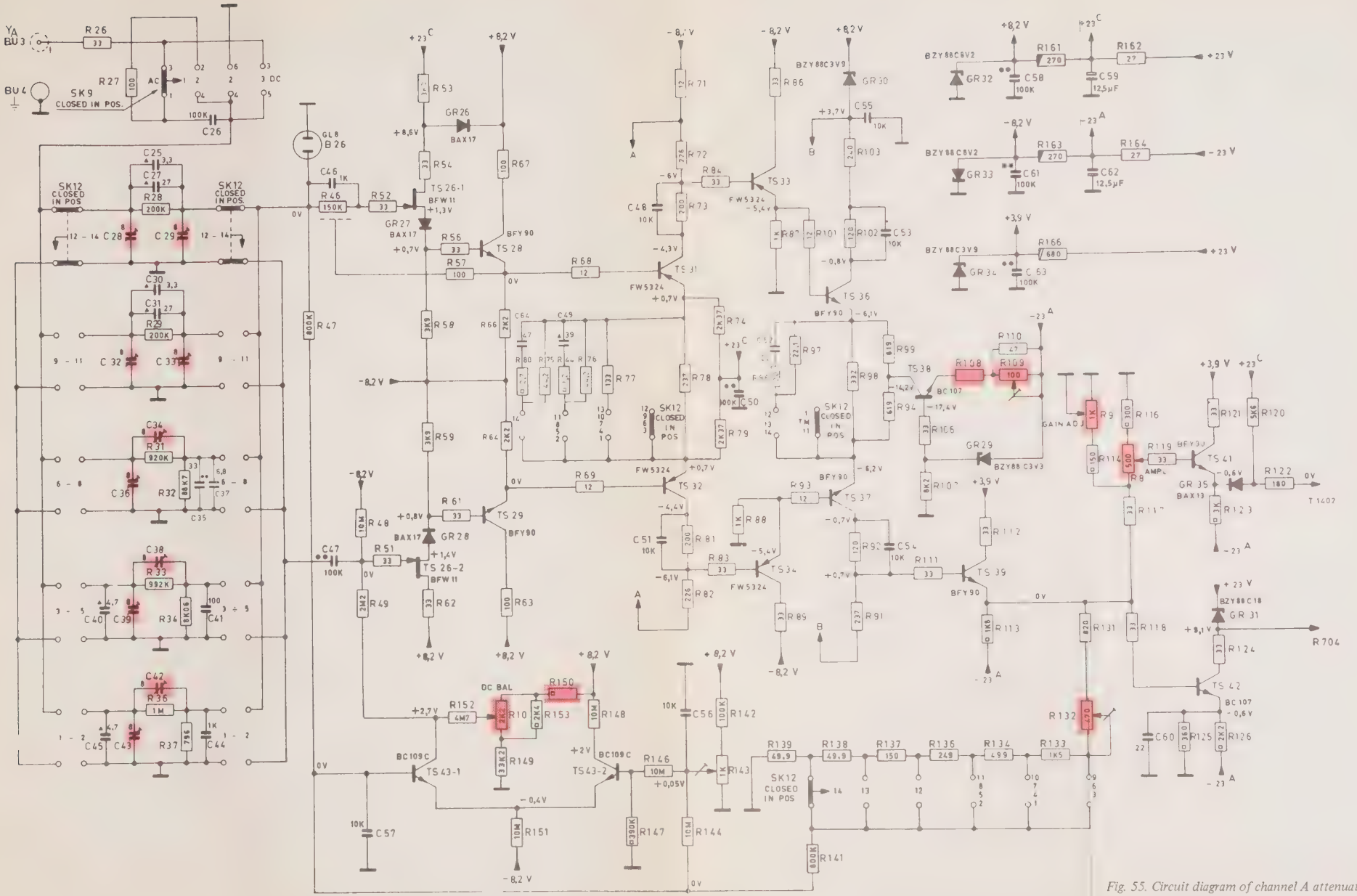


Fig. 55. Circuit diagram of channel A attenuator and pre-amplifier

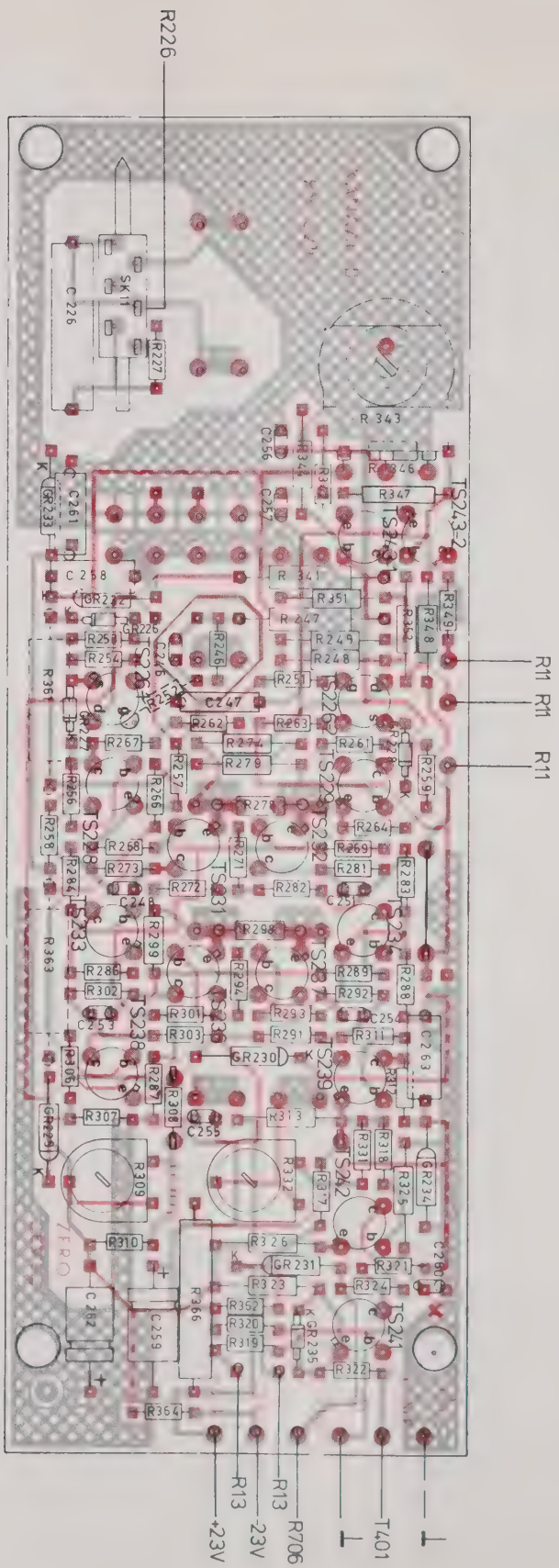


Fig. 56. Unit 2. Channel B vertical pre-amplifier

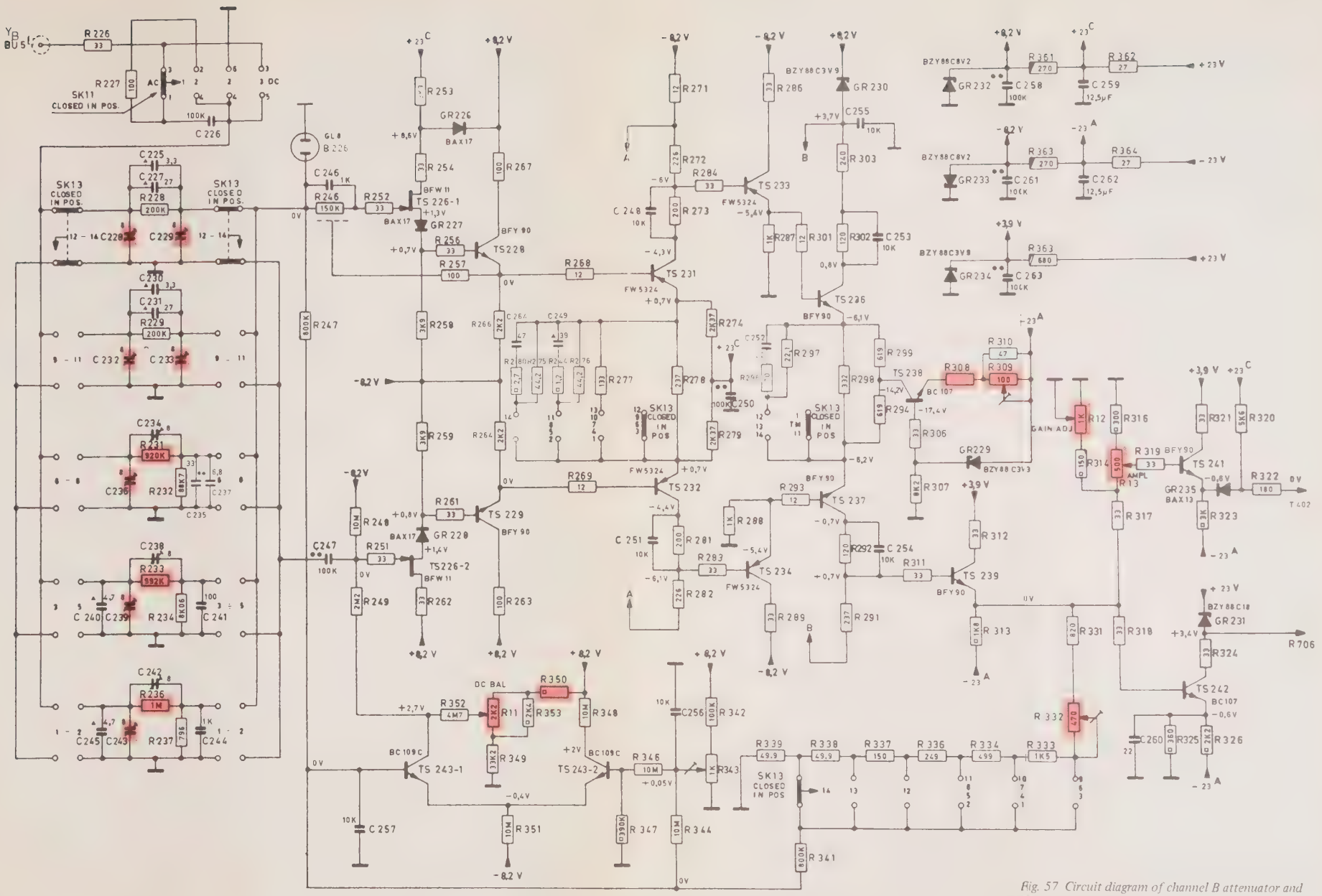


Fig. 57 Circuit diagram of channel B attenuator and pre-amplifier

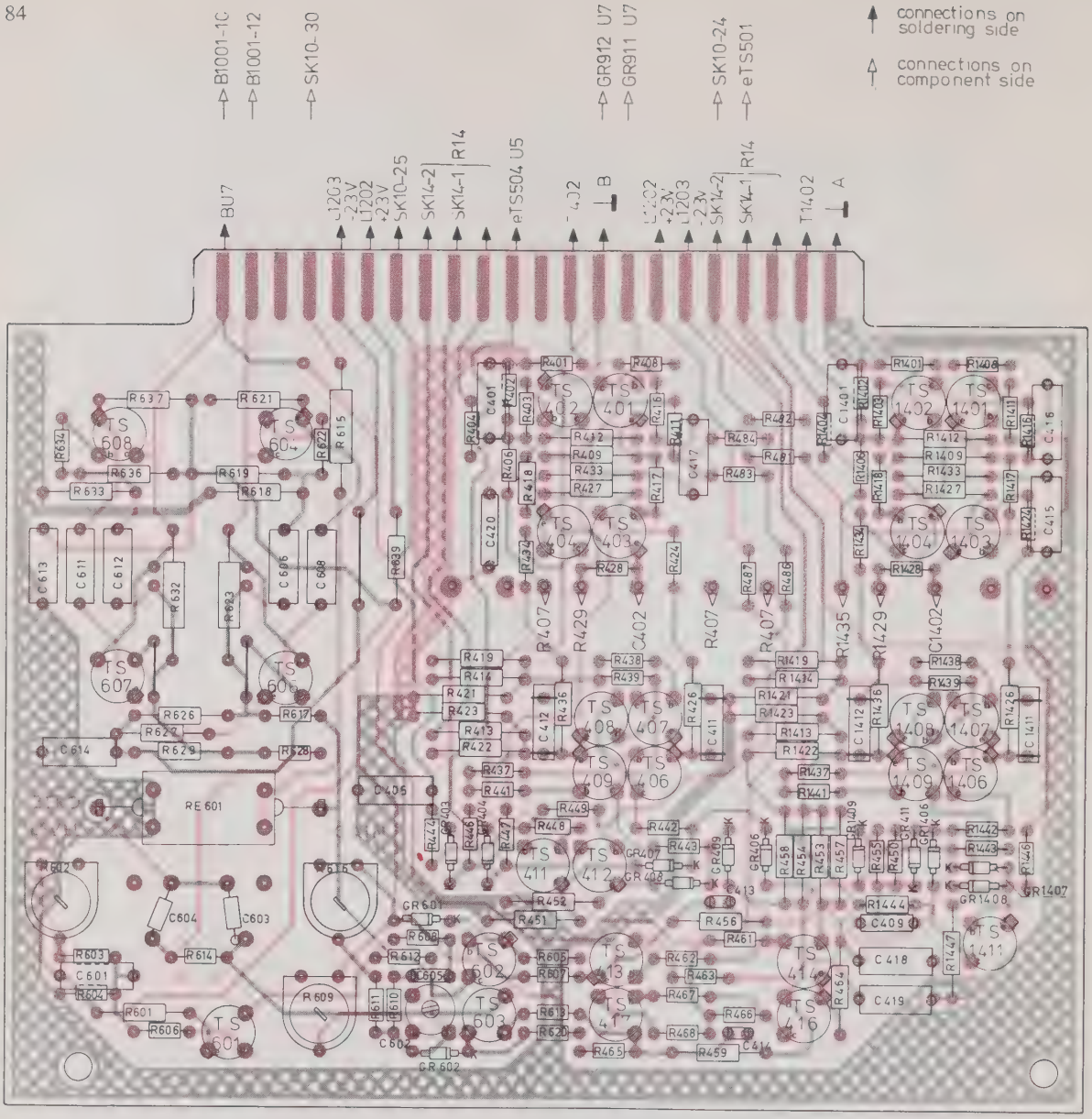


Fig. 58. Unit 4. Vertical amplifier

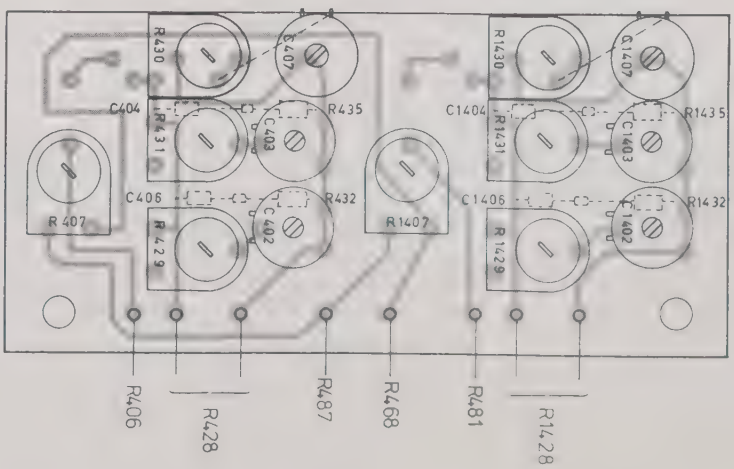


Fig. 58A. Unit 402. Adjusting unit

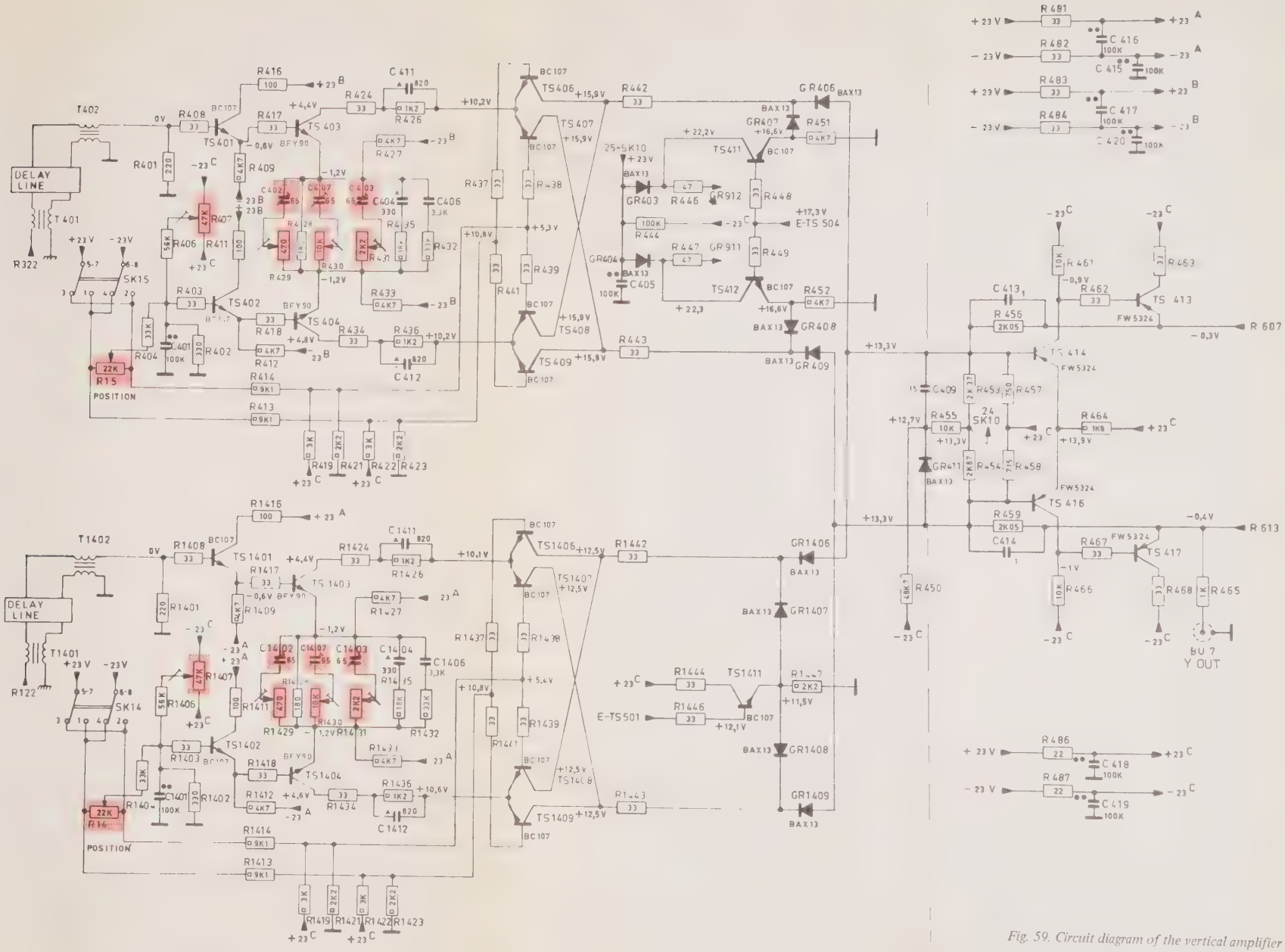


Fig. 59. Circuit diagram of the vertical amplifier

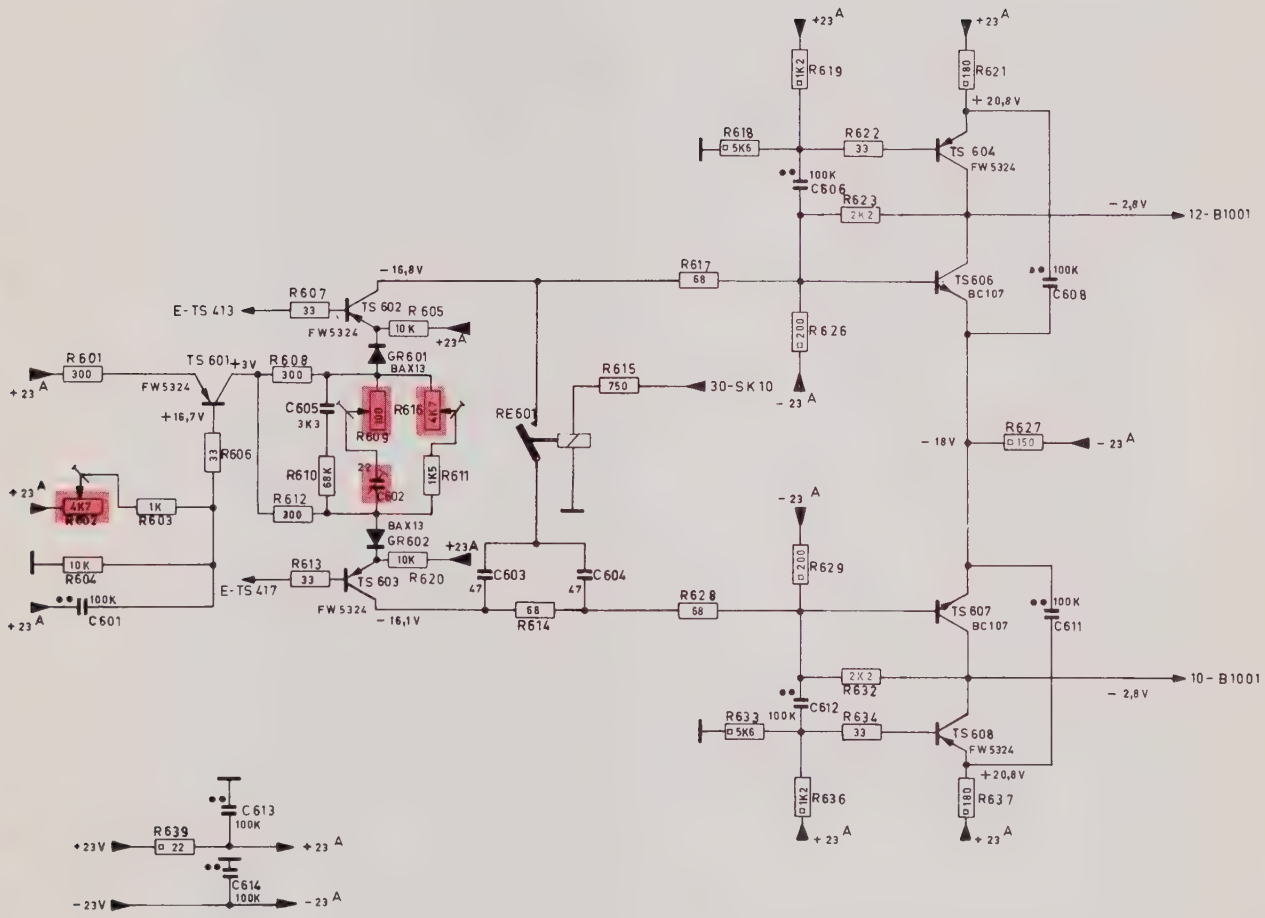


Fig. 60. Circuit diagram of the vertical output amplifier

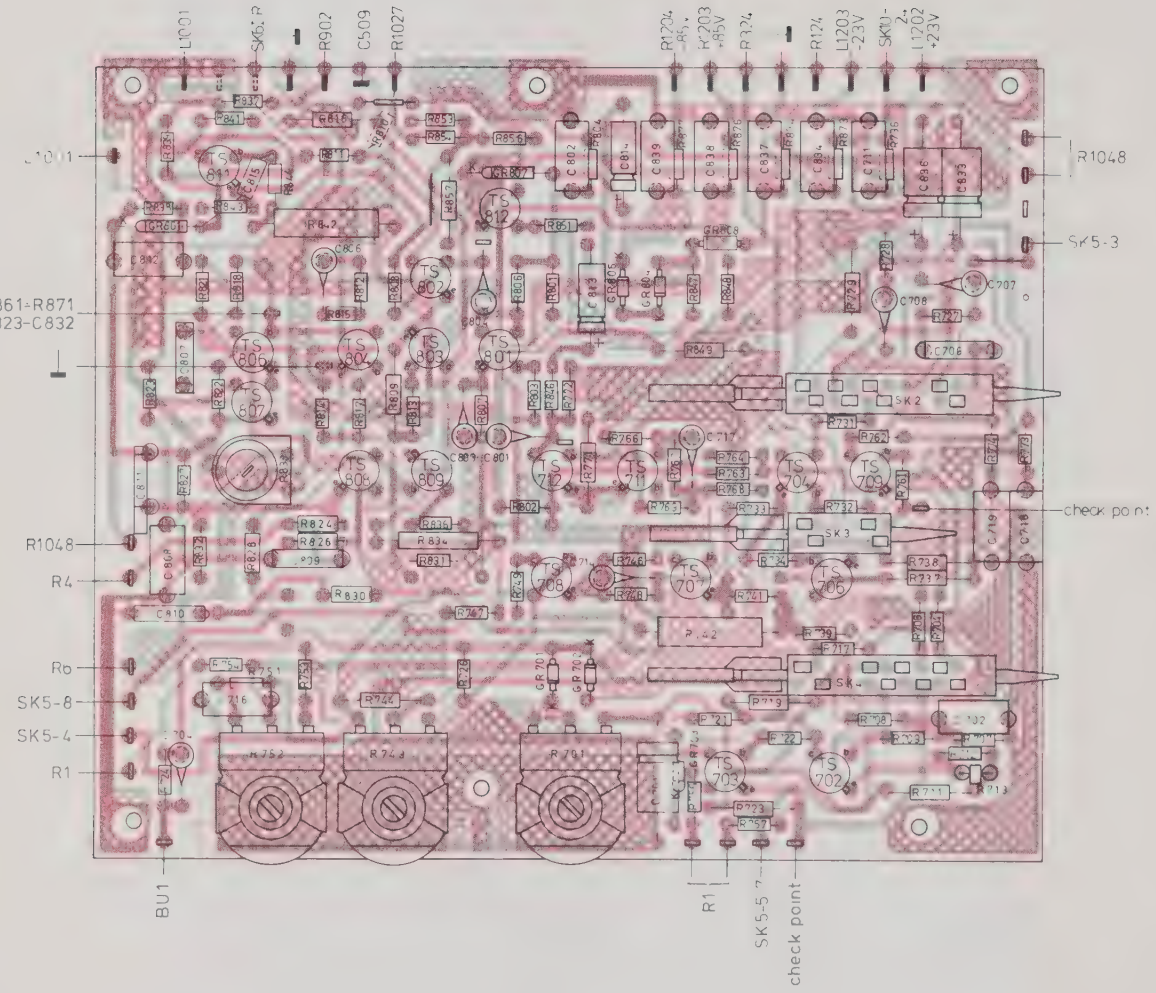


Fig. 61. Unit 3. Time-base and triggering

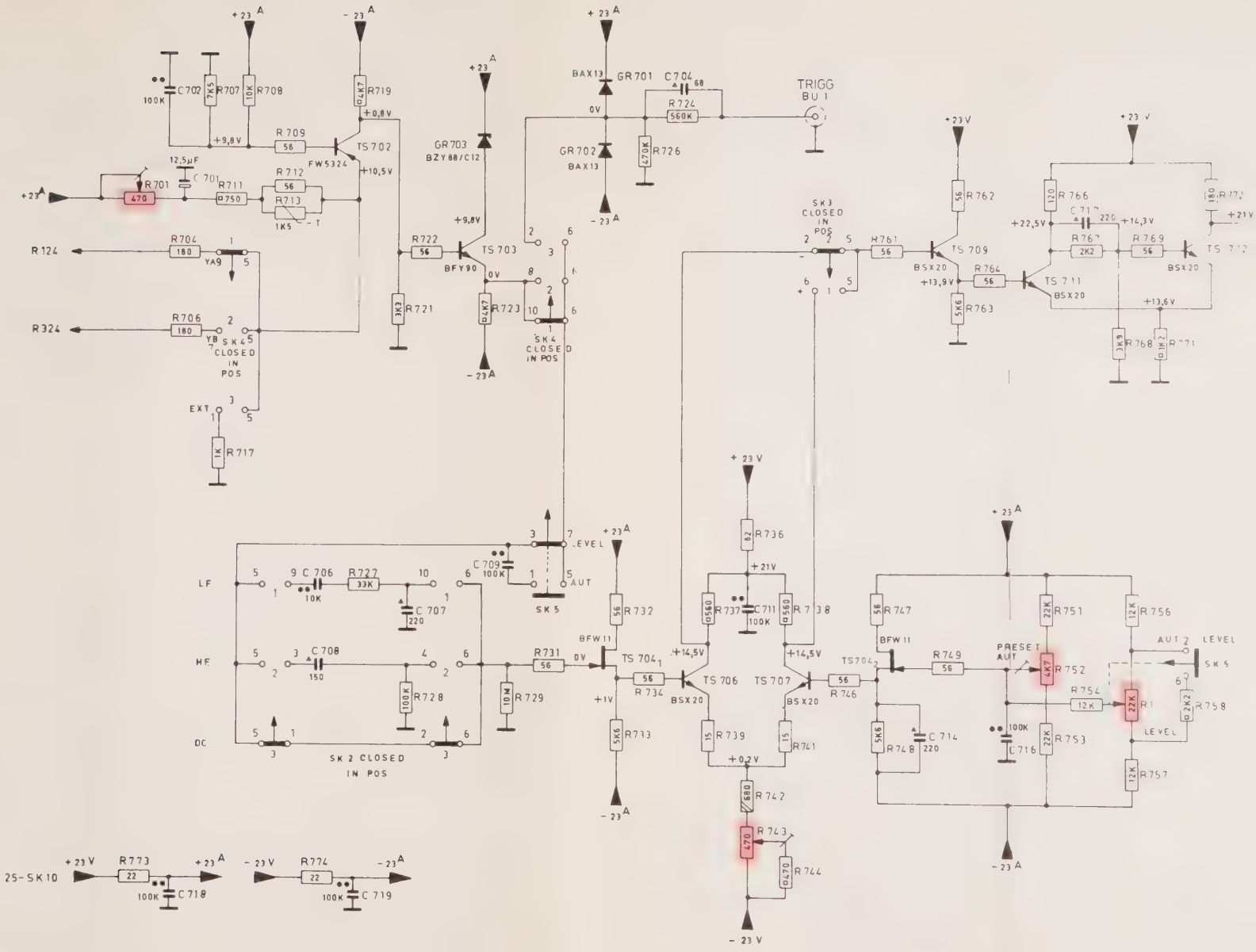


Fig. 62. Circuit diagram of the trigger amplifier

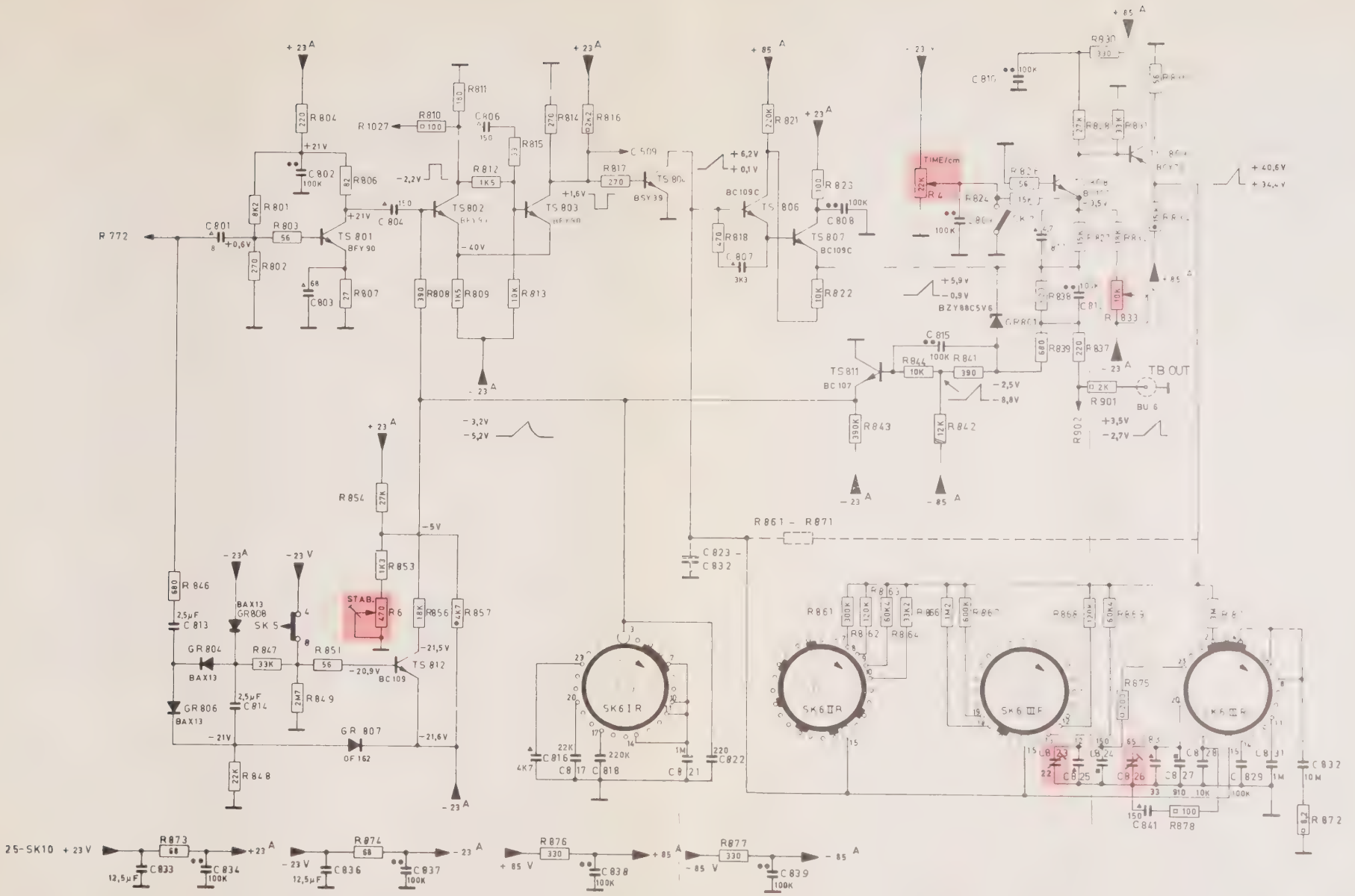


Fig. 63. Circuit diagram of the time-base generator

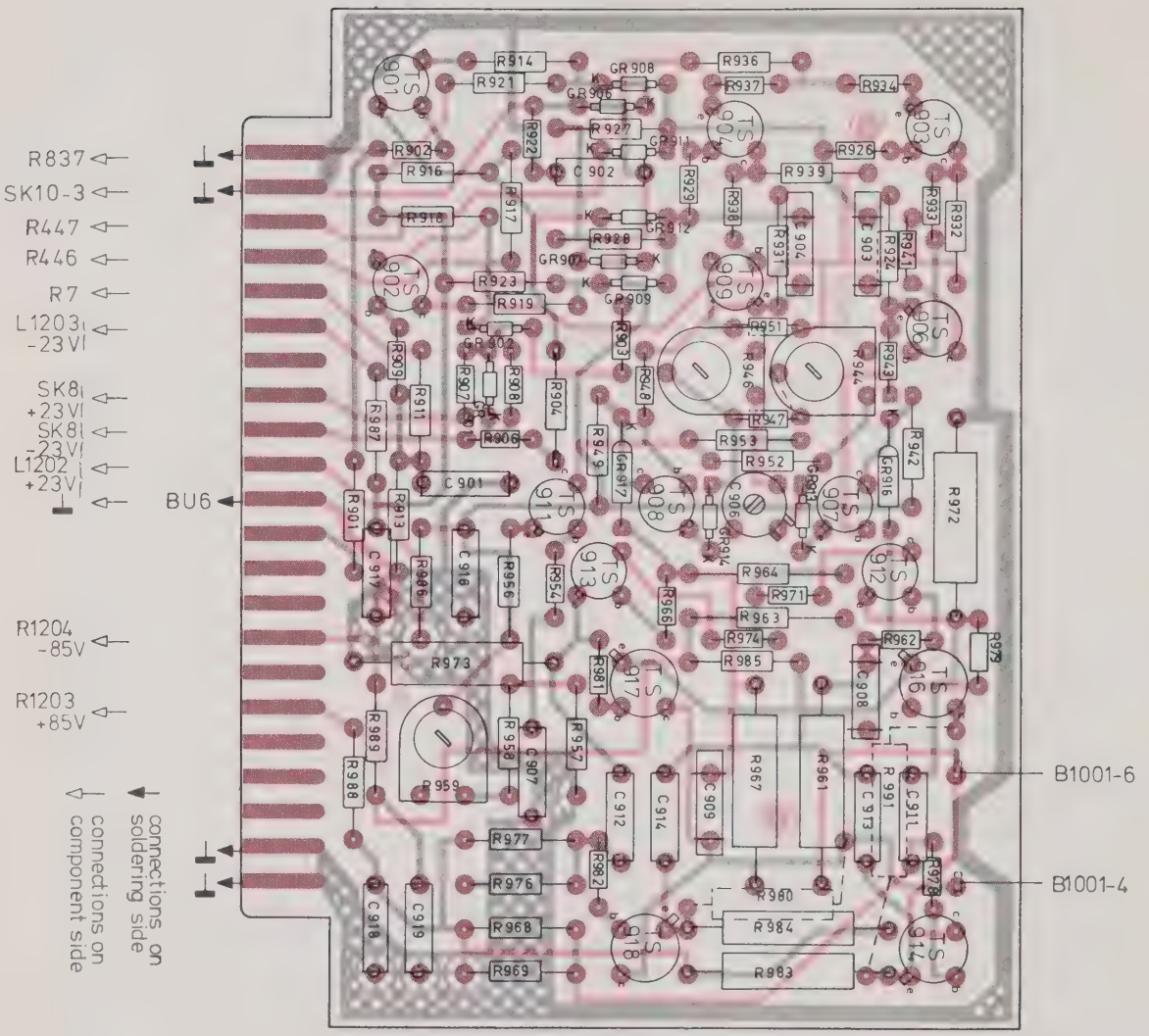


Fig. 64. Unit 7. Horizontal amplifier

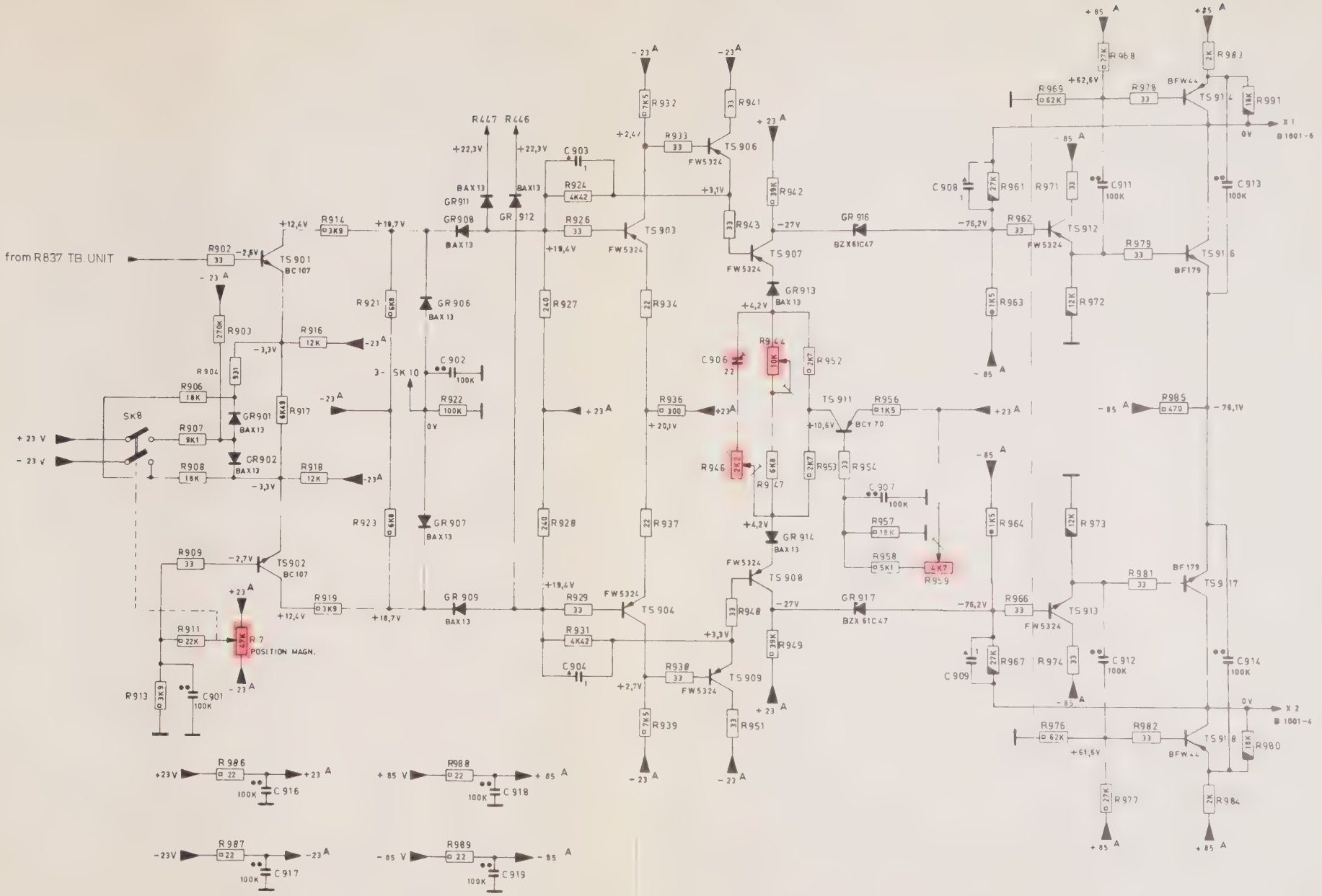


Fig. 65. Circuit diagram of the horizontal amplifier

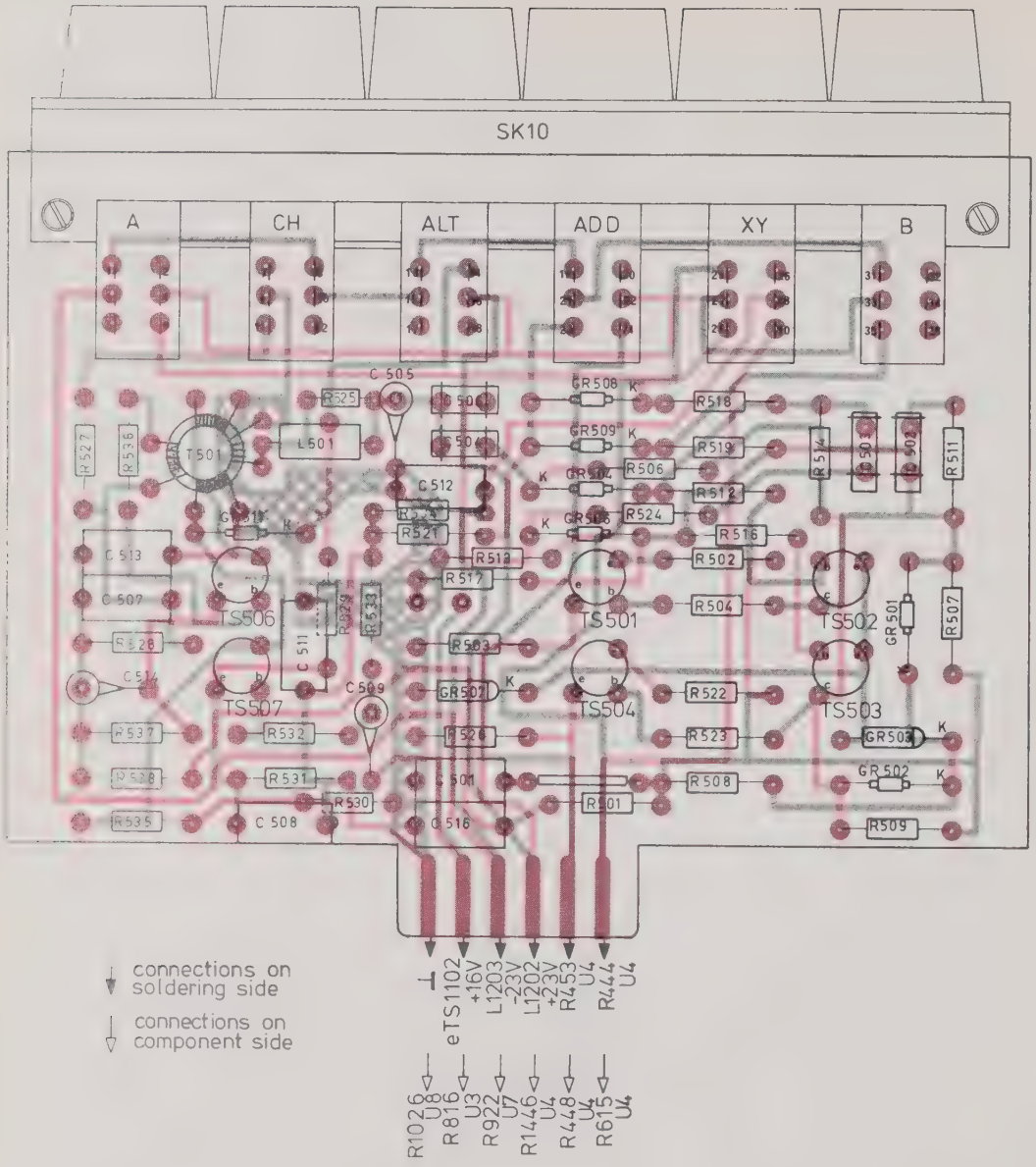


Fig. 66. Unit 5. Switch unit

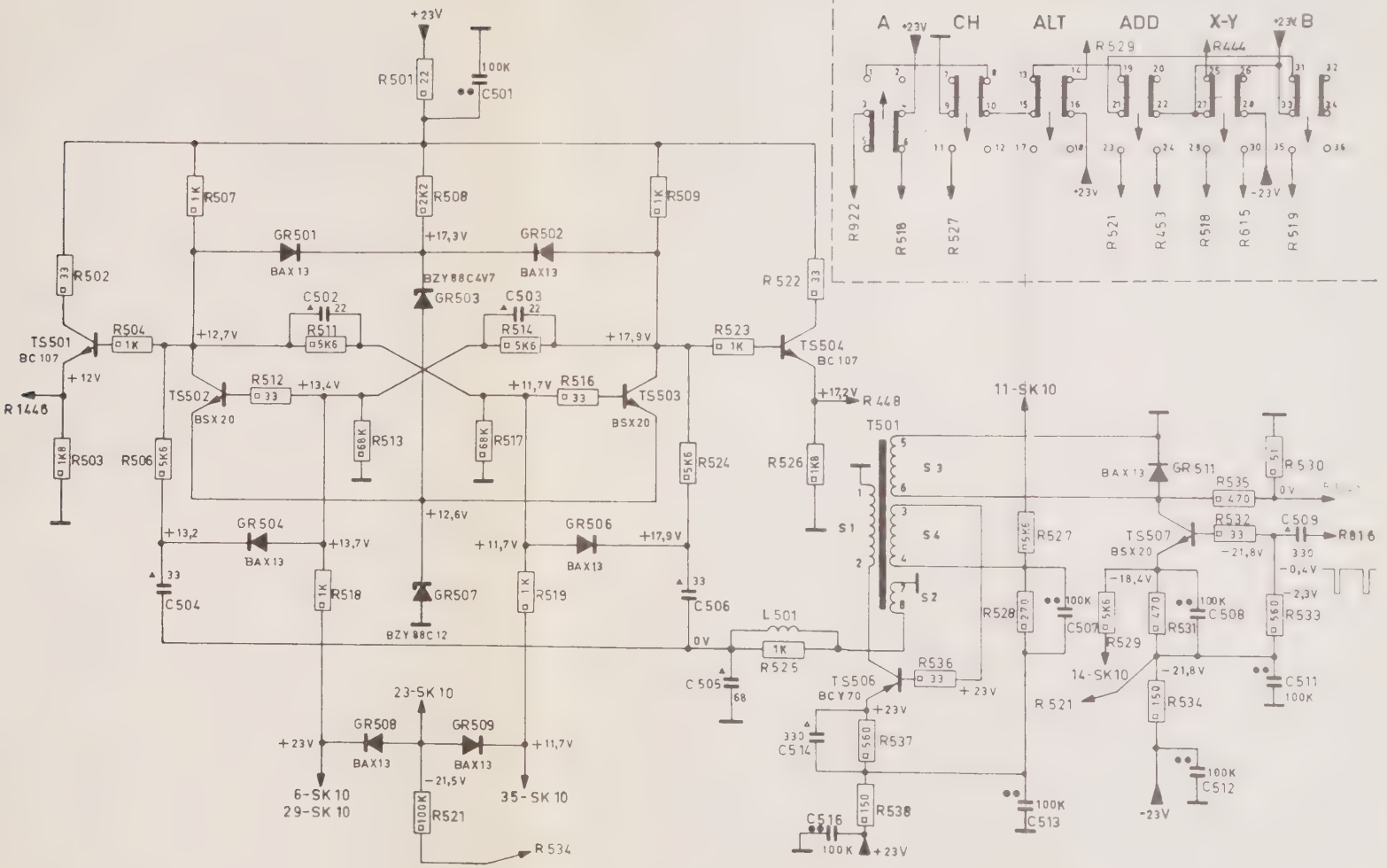


Fig. 67. Circuit diagram of the switch unit

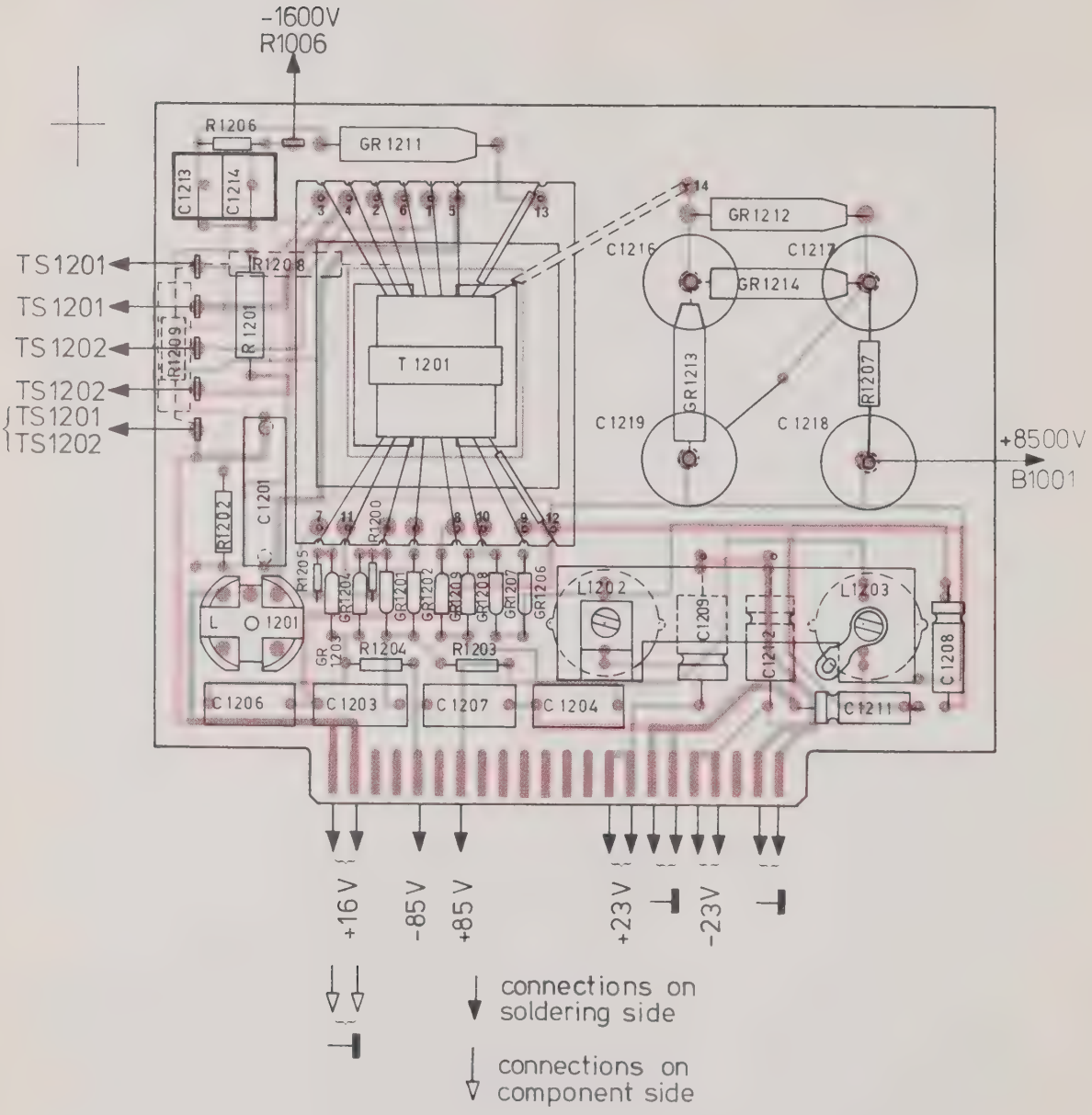
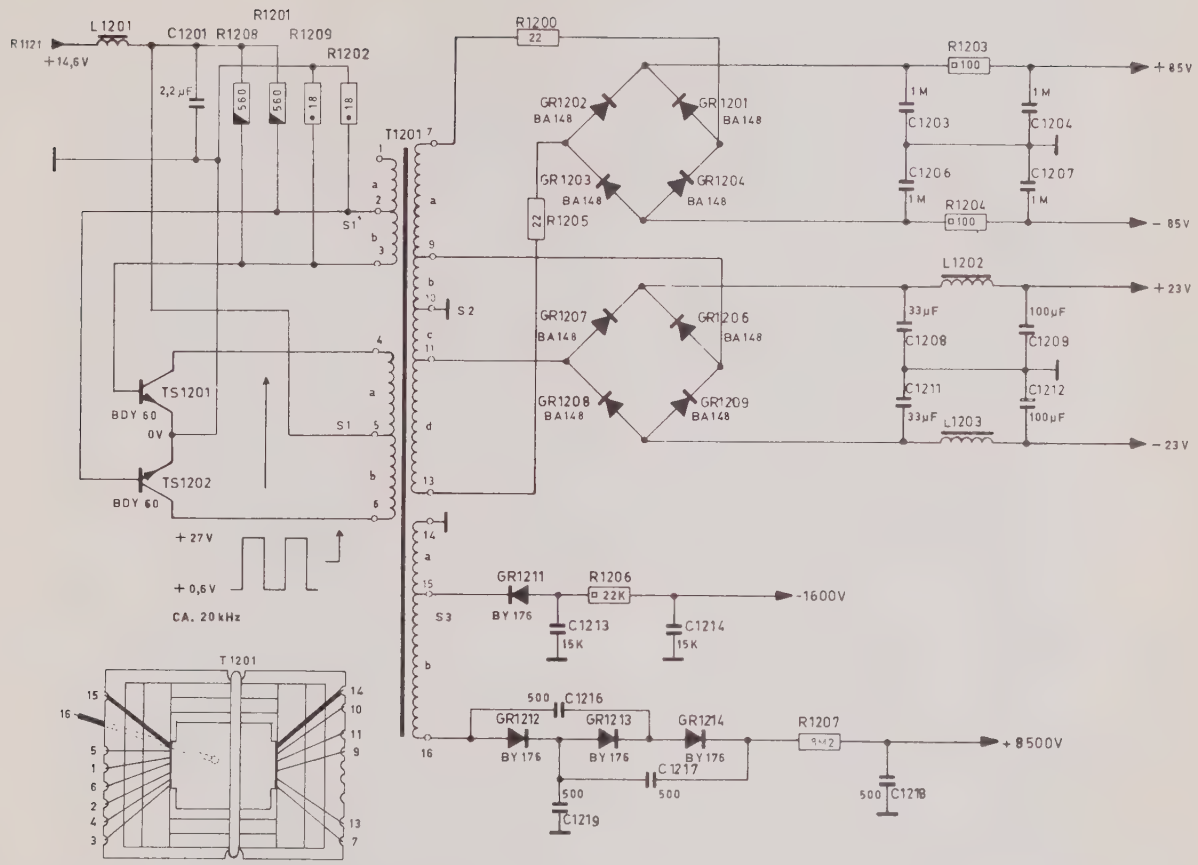


Fig. 68. Unit 6. Convertor unit



COIL	S1a	S1b	S1'a	S1'b	S2a	S2b	S2c	S2d	S3a	S3b
TURNS	5	5	1	1	26	9	9	26	535	400

Fig. 69. Circuit diagram of the convertor unit

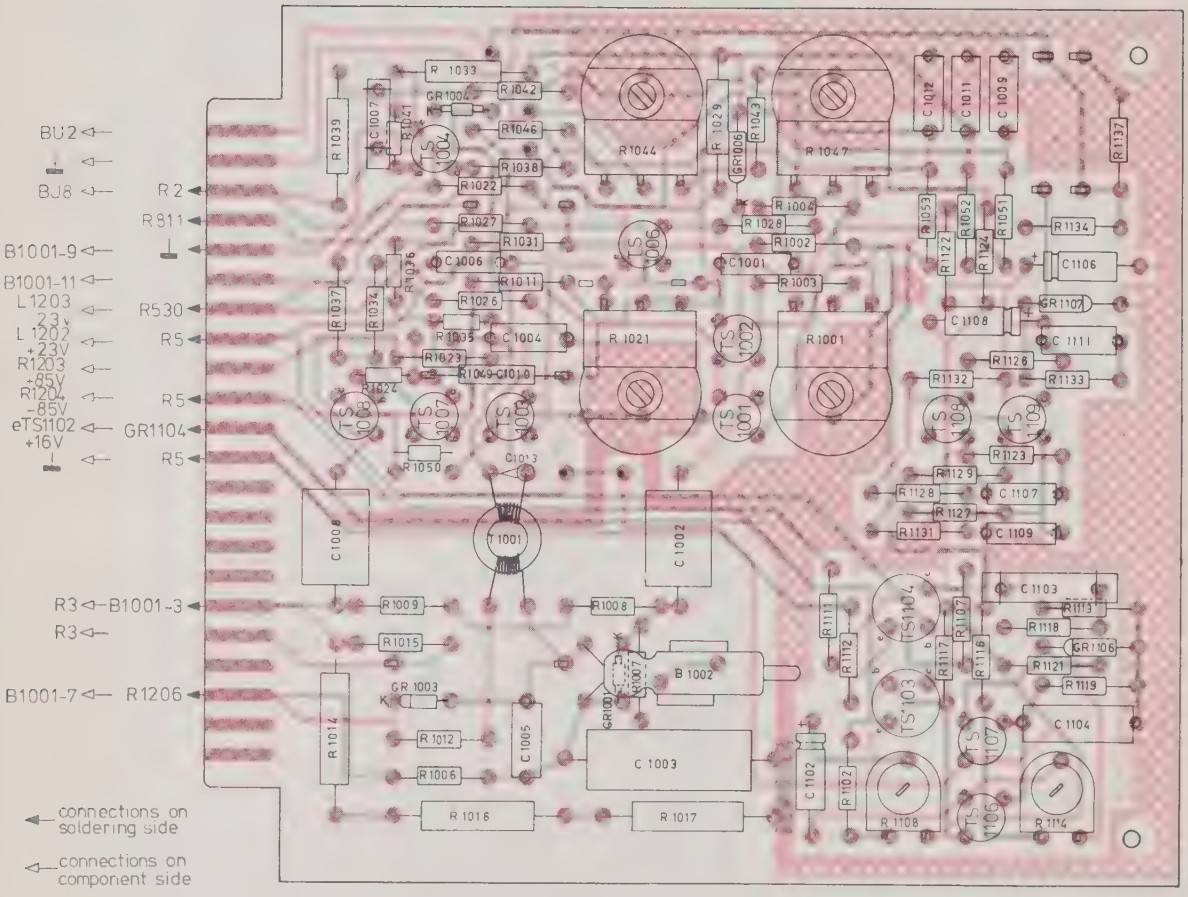


Fig. 70. Unit 8. Combination unit

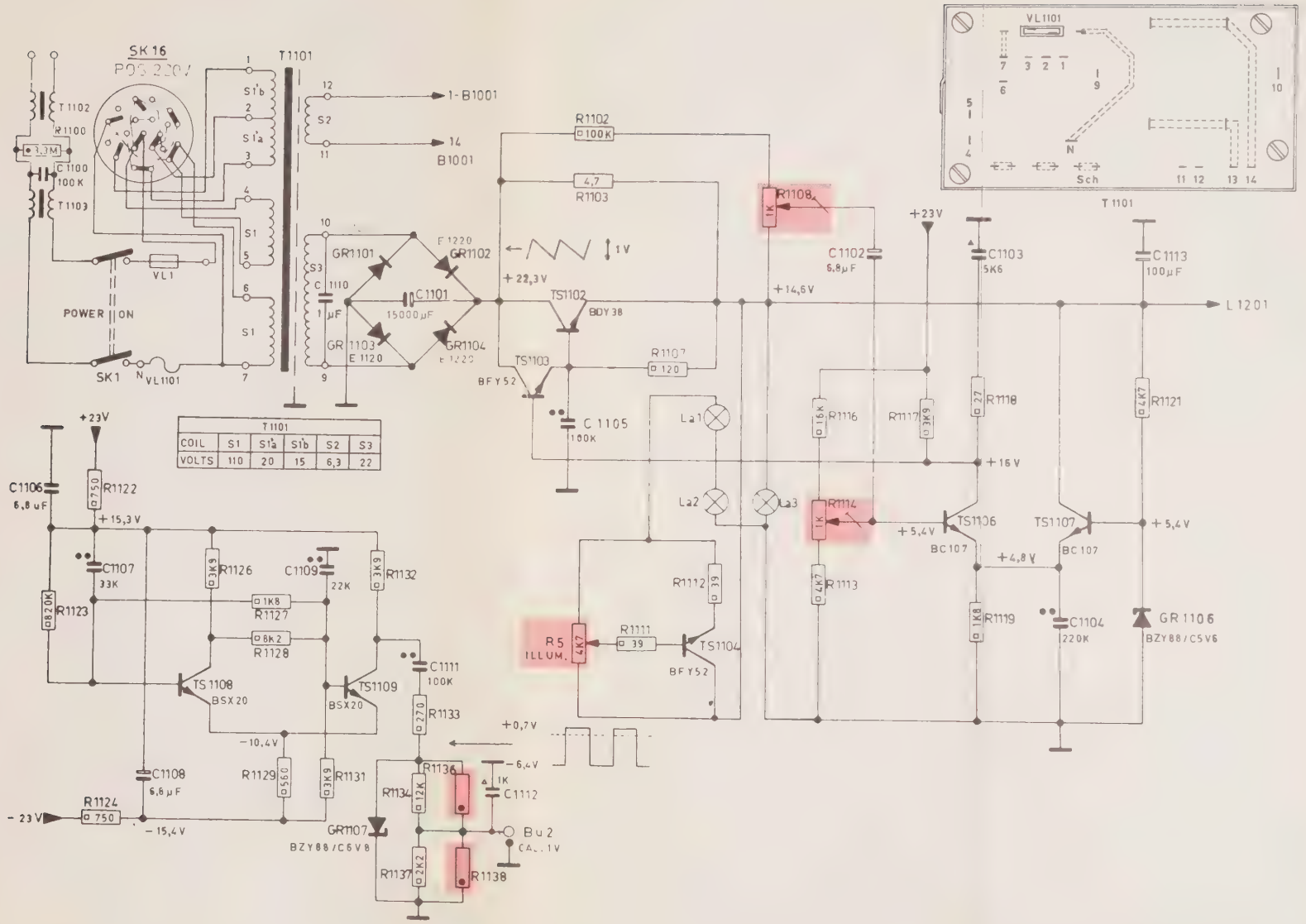


Fig. 71. Circuit diagram of the stabilized power supply and the calibration unit

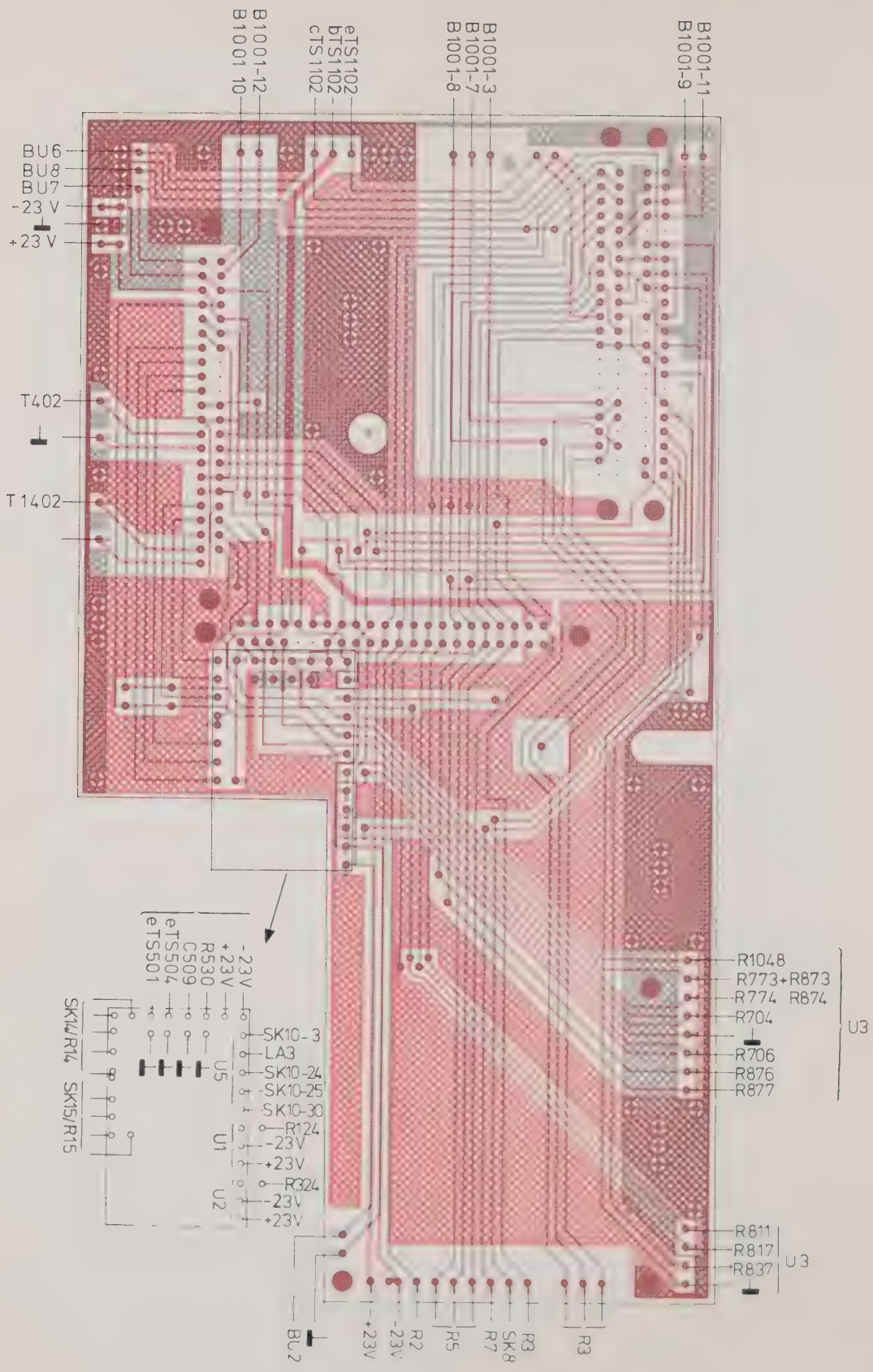


Fig. 72. Unit 9. Wiring unit

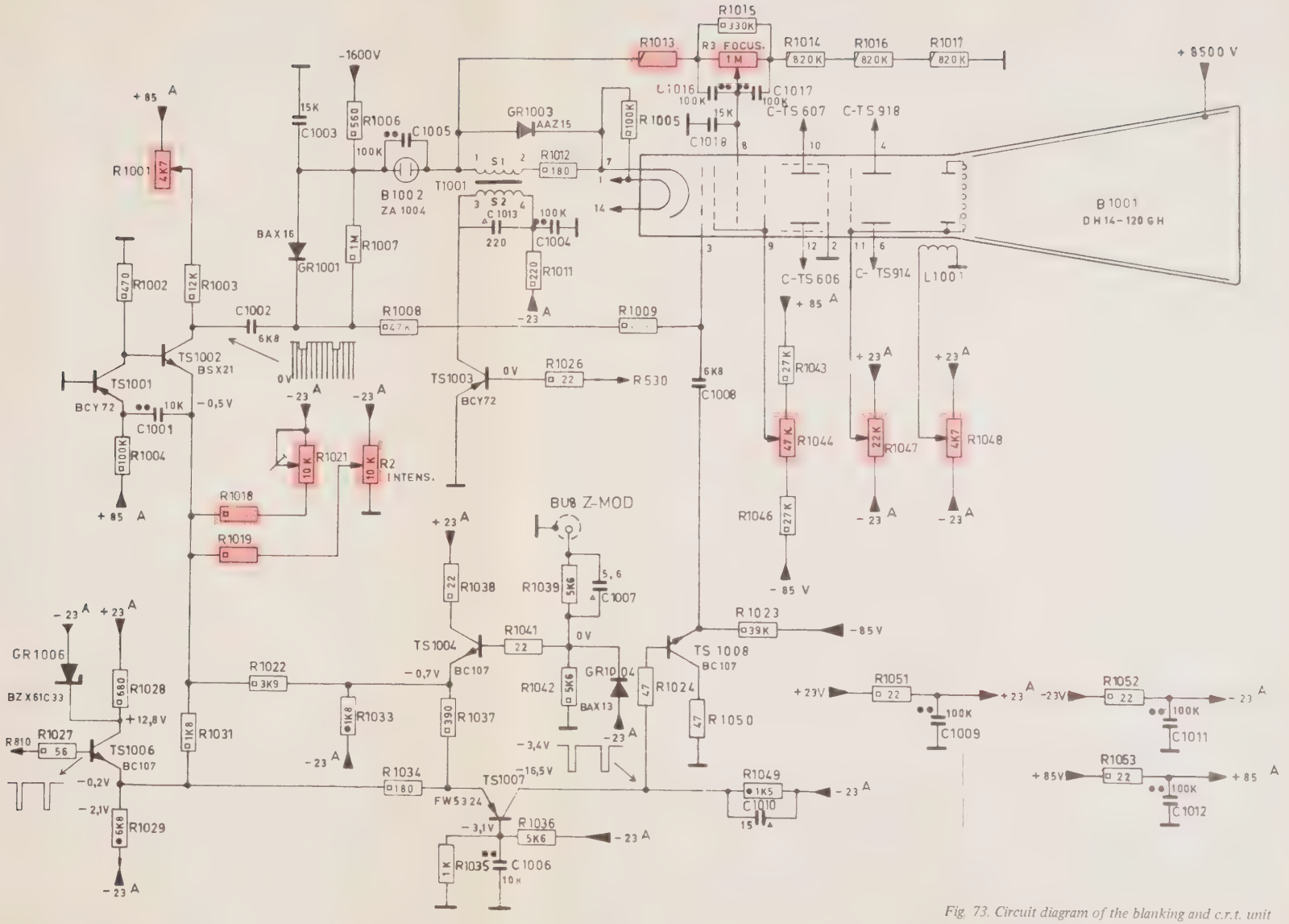


Fig. 73. Circuit diagram of the blanking and c.r.t. unit

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Fig. 79 Bottom view with item numbers 125

XII. Mechanical parts list

Item	Fig.	Qty.	Ordering code	Description
1	74	1	5322 459 40233	Bezel
2	74	1	5322 450 60089	Graticule
3	74	1	5322 450 60091	Contrast filter, grey
4	74	1	5322 450 60092	Contrast filter, green
5	74	1	5322 277 10226	Mains switch
6	74	5	5322 404 60058	Switch lever for SK2, 3, 4, 9, 11
7	74	3	5322 413 40112	Switch knob for SK6, 12, 13
8	74	3	5322 413 30085	Control knob for R4, 8, 13
9	74	3	5322 413 70039	Cap for item 8
10	74	4	5322 413 30082	Control knob for R1, 7, 14, 15
11	74	7	5322 413 70038	Cap for items 10 and 13
12	74	7	5322 267 10004	B.N.C. sockets BU1, 2, 3, 5, 6, 7, 8
13	74	3	5322 413 30346	Control knob for R2, 3, 5
14	74	1	5322 535 80523	Earth screw
15	74	6	5322 276 60103	Push-button switch for SK10
16	74	1	5322 455 80062	Text plate, front
17	74	1	5322 498 40324	Grip
18	74	2	5322 498 70044	Bracket
19	75	1	5322 256 40026	Fuse holder
20	75	1	5322 455 80063	Text plate, rear
21	75	1	5322 255 40091	Rear cover
22	75	1	5322 321 10071	Mains flex
23	76	2	5322 255 20022	Lamp holder
24	76	2	5322 462 70827	Cap
25	76	2	5322 255 40106	Transistor clip
26	76	16	5322 255 40057	Transistor holder
27	76	1	5322 320 20062	H.T. Cable
28	76	87	5322 255 40017	Transistor holder
29	76	4	5322 255 40105	Heat sink
30	76	3	5322 255 40085	Transistor holder
31	76	3	5322 255 40072	Mica insulation plate
32	77	4	5322 267 60034	Terminal
33	77	4	5322 255 40054	Heat sink
34	77	6	5322 255 40015	Transistor holder
35	77	1	5322 277 30518	Switch SK2
36	77	1	5322 277 30519	Switch SK3
37	77	1	5322 277 30521	Switch SK4
38	78	2	5322 277 30517	Switch SK9, SK11
39	78	1	5322 273 60103	Time-base switch SK6
40	78	1	5322 532 80121	Capacitor support

Item	Fig.	Qty.	Ordering code	Description
41	78	1	5322 272 10003	Voltage adapter
42	79	1	5322 255 10007	Lamp holder
43	79	1	5322 267 40134	Terminal
44	79	1	5322 105 30068	Attenuator unit 1, for channel A
45	79	1	5322 105 30069	Attenuator unit 2, for channel B
46	79	1	5322 219 80241	Rotor assembly for unit 1
47	79	1	5322 219 80242	Rotor assembly for unit 2
48	–	2	5322 492 61786	Earthing spring for units 1 & 2
49	77	1	5322 216 50216	Time-base unit 3
50	76	1	5322 216 50217	Y Amplifier unit 4
51	76	1	5322 216 50218	Adjusting unit 402
52	79	1	5322 216 50219	Switch unit 5
53	78	1	5322 219 80243	H.T. Unit 6
54	77	1	5322 216 50221	X Amplifier unit 7
55	77	1	5322 216 50222	Blanking & calibration unit 8
56	79	1	5322 320 40041	Delay line unit
57	–	1	5322 395 50104	Trimming rod

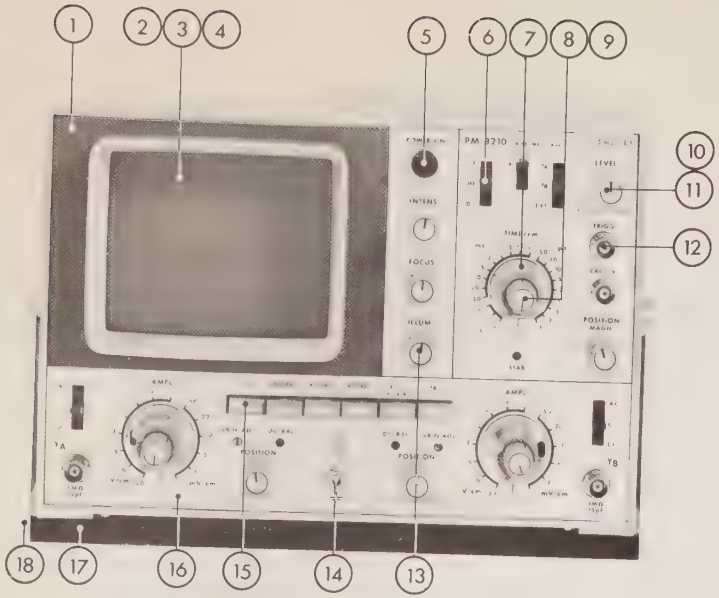


Fig. 74. Front view with item numbers

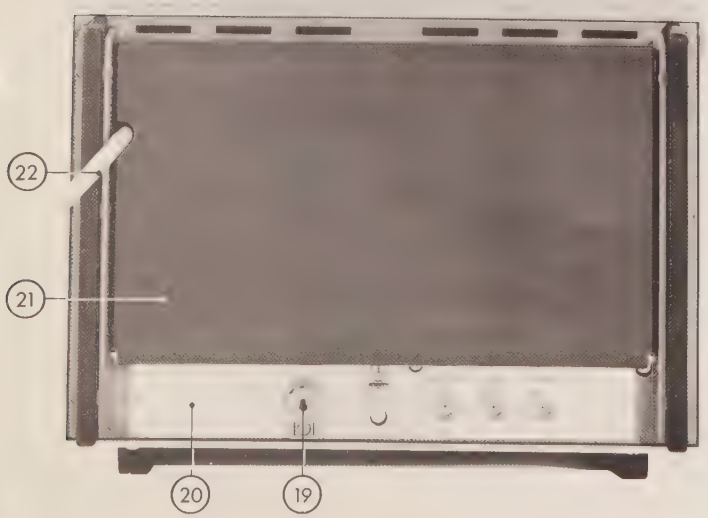


Fig. 75. Rear view with item numbers

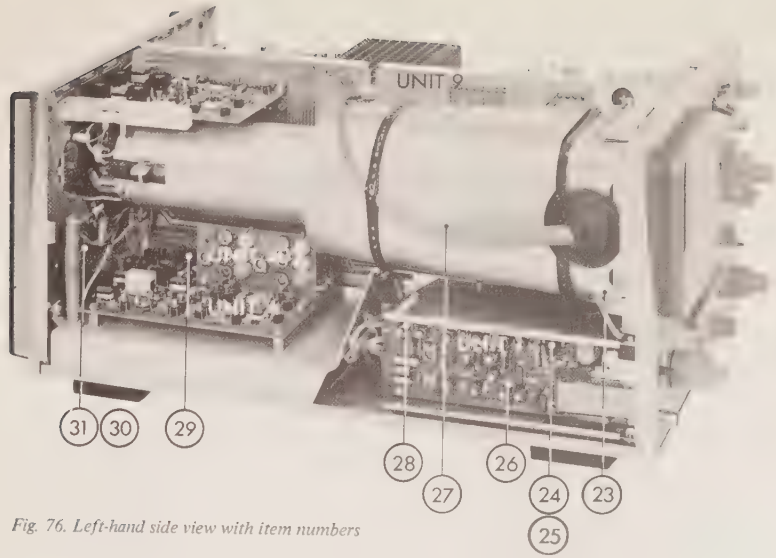


Fig. 76. Left-hand side view with item numbers

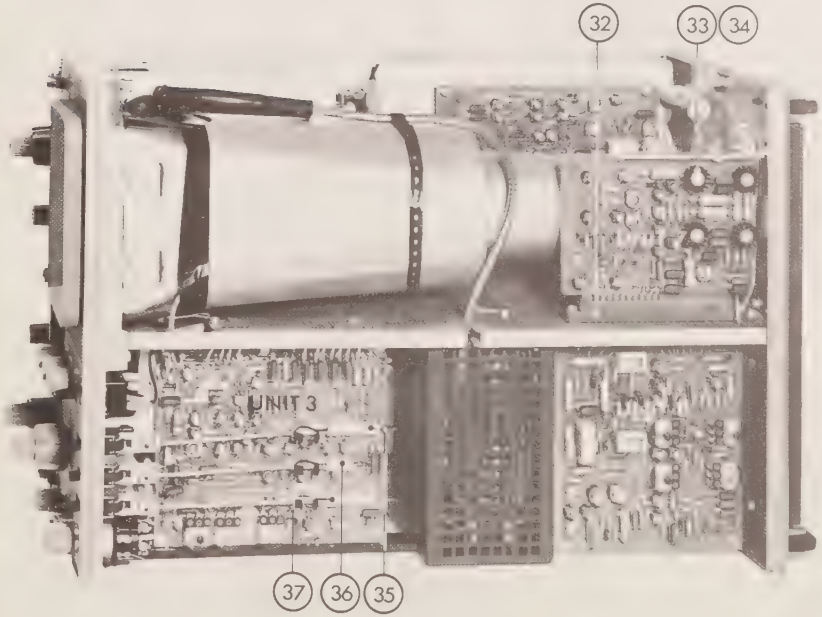


Fig. 77. Top view with item numbers

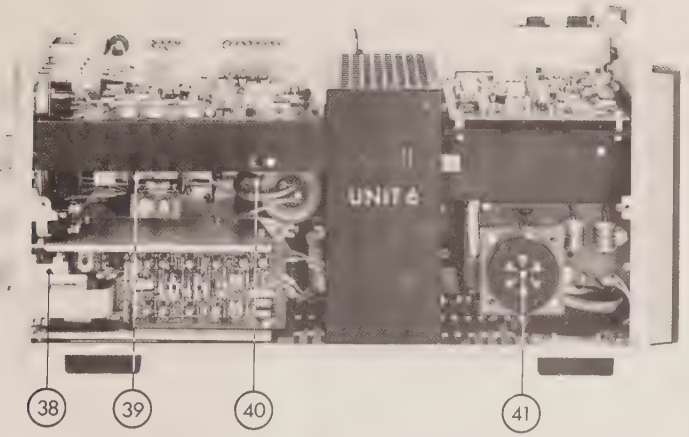


Fig. 78. Right-hand side view with item numbers

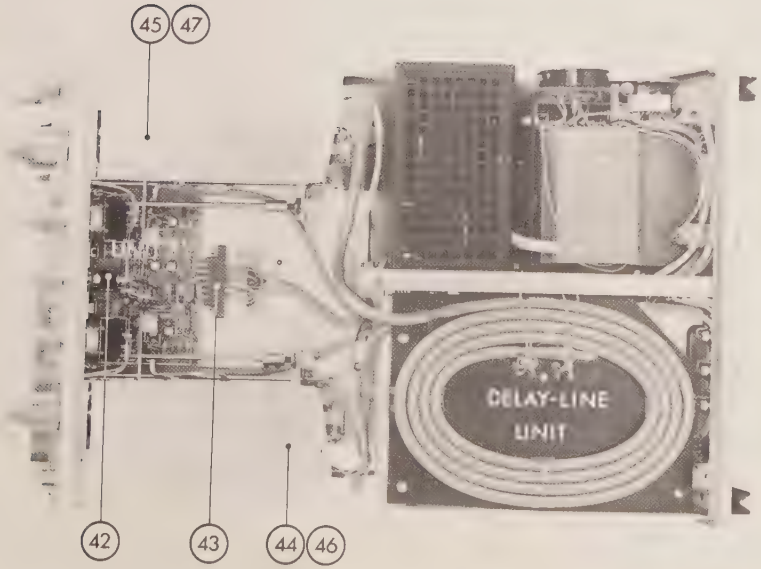


Fig. 79. Bottom view with item numbers

XIII. Electrical parts list

This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

Carbon resistor E24 series Kohleschichtwiderstand, Reihe E24 Koolweerstand E24 reeks Résistance au carbone, série E24 Resistencia de carbón, serie E24	0,125 W	5%
Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	0,25 W	1 MΩ, 5% 1 MΩ, 10%
Carbon resistor E24 series Kohleschichtwiderstand, Reihe E24 Koolweerstand E24 reeks Résistance au carbone, série E24 Resistencia de carbón, serie E24	0,5 W	≦ 5 MΩ, 1% > 5 ≦ 10 MΩ, 2% > 10 MΩ, 5%
Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	0,5 W	≦ 1,5 MΩ, 5% > 1,5 MΩ, 10%
Wire-wound resistor Drahtwiderstand Draadgewonden weerstand Résistance bobinée Resistencia bobinada	10 W	5%
Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	1 W	≦ 2,2 MΩ, 5% > 2,2 MΩ, 10%
Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	2 W	5%
Wire-wound resistor Drahtwiderstand Draadgewonden weerstand Résistance bobinée Resistencia bobinada	0,4 – 1,8 W	0,5%
Wire-wound resistor Drahtwiderstand Draadgewonden weerstand Résistance bobinée Resistencia bobinada	5,5 W	≦ 200 Ω, 10% > 200 Ω, 5%

Tubular ceramic capacitor Rohrkondensator Keramische kondensator, buistype Condensateur céramique tubulaire Condensador cerámico tubular	500 V
Tubular ceramic capacitor Rohrkondensator Keramische kondensator, buistype Condensateur céramique tubulaire Condensador cerámico tubular	700 V
Ceramic capacitor, "pin-up" Keramikkondensator "Pin-up" (Perltyp) Keramische kondensator "Pin-up" type Condensateur céramique, type perle Condensador cerámico, versión "colgable"	500 V
"Microplate" ceramic capacitor Miniatur-Scheibenkondensator "Microplate" keramische kondensator Condensateur céramique "microplate" Condensador cerámico "microplaca"	30 V
Mica capacitor Glimmerkondensator Micakondensator Condensateur au mica Condensador de mica	500 V
Polyester capacitor Polyesterkondensator Polyesterkondensator Condensateur au polyester Condensador polyester	400 V
Flat-foil polyester capacitor Miniatur-Polyesterkondensator (flach) Platte miniatuur polyesterkondensator Condensateur au polyester, type plat Condensador polyester, tipo de placas planas	250 V
Paper capacitor Papierkondensator Papierkondensator Condensateur au papier Condensador de papel	1000 V
Wire-wound trimmer Drahttrimmer Draadgewonden trimmer Trimmer à fil Trimmer bobinado	
Tubular ceramic trimmer Rohrtrimmer Buisvormige keramische trimmer Trimmer céramique tubulaire Trimmer cerámico tubular	

SERVICE

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.
Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.
Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.
Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.
Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

A. CAPACITORS

Item	Code number	Value	Volt	Description
C26	5322 121 40145	100 nF	630 V	Polyester
C28	5322 125 60067	8 pF	300 V	Trimmer
C29	5322 125 60067	8 pF	300 V	Trimmer
C32	5322 125 60067	8 pF	300 V	Trimmer
C33	5322 125 60067	8 pF	300 V	Trimmer
C34	5322 125 60067	8 pF	300 V	Trimmer
C35	4822 122 30016	33 pF	63 V	Miniature ceramic
C36	5322 125 60067	8 pF	300 V	Trimmer
C37	4822 122 70082	6.8 pF	350 V	Feed-through
C38	5322 125 60067	8 pF	300 V	Trimmer
C39	5322 125 60067	8 pF	300 V	Trimmer
C41	5322 123 10197	100 pF	300 V	Disc
C42	5322 125 60067	8 pF	300 V	Trimmer
C43	5322 125 60067	8 pF	300 V	Trimmer
C44	5322 123 10236	1 nF	300 V	Disc
C46	4822 122 30027	1 nF	100 V	Miniature ceramic
C48	4822 122 30043	10 nF	40 V	Miniature ceramic
C51	4822 122 30043	10 nF	40 V	Miniature ceramic
C52	5322 122 30022	22 pF	63 V	Miniature ceramic
C53	4822 122 30043	10 nF	40 V	Miniature ceramic
C54	4822 122 30043	10 nF	40 V	Miniature ceramic
C55	4822 122 30043	10 nF	40 V	Miniature ceramic
C56	4822 122 30043	10 nF	40 V	Miniature ceramic
C57	4822 122 30043	10 nF	40 V	Miniature ceramic
C59	4822 124 20355	12.5 μF	25 V	Electrolytic
C60	5322 122 30022	22 pF	63 V	Miniature ceramic
C62	4822 124 20355	12.5 μF	25 V	Electrolytic
C64	4822 122 30008	47 pF	63 V	Miniature ceramic
C226	5322 121 40145	100 nF	630 V	Polyester
C228	5322 125 60067	8 pF	300 V	Trimmer
C229	5322 125 60067	8 pF	300 V	Trimmer
C232	5322 125 60067	8 pF	300 V	Trimmer
C233	5322 125 60067	8 pF	300 V	Trimmer
C234	5322 125 60067	8 pF	300 V	Trimmer
C235	4822 122 30016	33 pF	63 V	Miniature ceramic
C236	5322 125 60067	8 pF	300 V	Trimmer
C237	4822 122 70082	6.8 pF	350 V	Feed-through
C238	5322 125 60067	8 pF	300 V	Trimmer
C239	5322 125 60067	8 pF	300 V	Trimmer
C241	5322 123 10197	100 pF	300 V	Disc
C242	5322 125 60067	8 pF	300 V	Trimmer
C243	5322 125 60067	8 pF	300 V	Trimmer
C244	5322 123 10236	1 nF	300 V	Disc
C246	4822 122 30027	1 nF	100 V	Miniature ceramic
C248	4822 122 30043	10 nF	40 V	Miniature ceramic
C251	4822 122 30043	10 nF	40 V	Miniature ceramic
C252	5322 122 30022	22 pF	63 V	Miniature ceramic
C253	4822 122 30043	10 nF	40 V	Miniature ceramic
C254	4822 122 30043	10 nF	40 V	Miniature ceramic
C255	4822 122 30043	10 nF	40 V	Miniature ceramic

Item	Code number	Value	Volt	Description
C256	4822 122 30043	10 nF	40 V	Miniature ceramic
C257	4822 122 30043	10 nF	40 V	Miniature ceramic
C259	4822 124 20355	12.5 µF	25 V	Electrolytic
C260	5322 122 30022	22 pF	63 V	Miniature ceramic
C262	4822 124 20355	12.5 µF	25 V	Electrolytic
C264	4822 122 30008	47 pF	63 V	Miniature ceramic
C402	4822 125 50017	65 pF	50 V	Trimmer
C403	4822 125 50017	65 pF	50 V	Trimmer
C404	5322 122 34005	330 pF	63 V	Miniature ceramic
C406	4822 122 30099	3.3 nF	100 V	Miniature ceramic
C407	4822 125 50017	65 pF	50 V	Trimmer
C409	4822 122 30097	15 pF	63 V	Miniature ceramic
C413	4822 122 30104	1 pF	63 V	Miniature ceramic
C414	4822 122 30104	1 pF	63 V	Miniature ceramic
C602	4822 125 50045	22 pF	100 V	Miniature ceramic
C603	4822 122 30008	47 pF	63 V	Miniature ceramic
C604	4822 122 30008	47 pF	63 V	Miniature ceramic
C605	4822 122 30099	3.3 nF	100 V	Miniature ceramic
C701	4822 124 20355	12.5 µF	25 V	Electrolytic
C813	4822 124 20095	2.5 µF	64 V	Electrolytic
C814	4822 124 20095	2.5 µF	64 V	Electrolytic
C817	4822 121 40171	22 nF	250 V	Polyester
C818	4822 121 40061	220 nF	250 V	Polyester
C821	5322 121 40176	1 µF	100 V	Polyester
C822	4822 120 10089	220 pF	700 V	Ceramic
C823	4822 125 50045	22 pF	50 V	Trimmer
C826	4822 125 50017	65 pF	50 V	Trimmer
C828		10 nF	200 V	
C829	5322 111 30192	100 nF	200 V	Box-capacitor
C831		1 µF	200 V	
C832	5322 121 10105	10 µF	200 V	Box-capacitor
C833	4822 124 20355	12.5 µF	25 V	Electrolytic
C836	4822 124 20355	12.5 µF	25 V	Electrolytic
C906	4822 125 50045	22 pF	50 V	Trimmer
C1002	4822 121 40326	6.8 nF	1600 V	Polyester
C1003	5322 121 40123	15 nF	1600 V	Polyester
C1008	5322 121 40326	6.8 nF	1600 V	Polyester
C1018	5322 121 40123	15 nF	1600 V	Polyester
C1100	5322 121 20173	100 nF	250 V	Paper/Polyester
C1101	5322 124 70222	2x7500 µF	25 V	Electrolytic
C1102	4822 124 20351	6.8 µF	40 V	Electrolytic
C1106	4822 124 20351	6.8 µF	40 V	Electrolytic
C1108	4822 124 20351	6.8 µF	40 V	Electrolytic
C1110	4822 121 40013	1 µF	250 V	Polyester
C1113	5322 124 20337	100 µF	40 V	Electrolytic
C1201	4822 121 40177	2.2 µF	250 V	Polyester
C1203	5322 121 40197	1 µF	100 V	Polyester
C1204	5322 121 40197	1 µF	100 V	Polyester
C1206	5322 121 40197	1 µF	100 V	Polyester
C1207	5322 121 40197	1 µF	100 V	Polyester

Item	Code number	Value	Volt	Description
C1208	4822 124 20366	33 µF	40 V	Electrolytic
C1209	5322 124 20337	100 µF	40 V	Electrolytic
C1211	4822 124 20366	33 µF	40 V	Electrolytic
C1212	5322 124 20337	100 µF	40 V	Electrolytic
C1213	5322 121 40123	15 nF	1600 V	Polyester
C1214	5322 121 40123	15 nF	1600 V	Polyester
C1216	5322 121 30077	500 pF	10 kV	High tension
C1217	5322 121 30077	500 pF	10 kV	High tension
C1218	5322 121 30077	500 pF	10 kV	High tension
C1219	5322 121 30077	500 pF	10 kV	High tension
C1402	4822 125 50017	65 pF	50 V	Trimmer
C1403	4822 125 50017	65 pF	50 V	Trimmer
C1404	5322 122 34005	330 pF	63 V	Miniature ceramic
C1406	5322 122 30099	3.3 nF	100 V	Miniature ceramic
C1407	4822 125 50017	65 pF	50 V	Trimmer

B. RESISTORS

Item	Code number	Value		Watt	%	Description
R1	5322 101 60048	22	kΩ	0.125	20	Potentiometer with switch (SK5)
R2	4822 101 30229	10	kΩ	0.125	20	Potentiometer
R3	5322 101 20376	1	MΩ	0.125	20	Potentiometer
R4	5322 101 40072	22	kΩ	0.125	20	Potentiometer with switch (SK7)
R5	5322 101 20341	4.7	kΩ	0.125	20	Potentiometer
R6	5322 101 20267	470	Ω	0.1	20	Potentiometer
R7	4822 101 60055	47	kΩ	0.125	20	Potentiometer with switch (SK8)
R8	5322 101 20422	500	Ω	0.125	20	Potentiometer
R9	5322 101 20288	1	kΩ	0.1	20	Potentiometer
R10	4822 101 20424	2.2	kΩ	0.1	20	Potentiometer
R11	4822 101 20424	2.2	kΩ	0.1	20	Potentiometer
R12	5322 101 20288	1	kΩ	0.1	20	Potentiometer
R13	4822 101 20224	500	Ω	0.125	20	Potentiometer
R14	5322 101 60048	22	kΩ	0.125	20	Potentiometer with switch (SK14)
R15	5322 101 60048	22	kΩ	0.125	20	Potentiometer with switch (SK15)
R26	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R27	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R28	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R29	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R31	4822 111 20332	920	kΩ	0.25	1	Carbon resistor
R32	5322 116 50821	88.7	kΩ	0.25	1	Metal film resistor
R33	4822 111 20333	992	kΩ	0.25	1	Carbon resistor
R34	5322 116 50914	8.06	kΩ	0.25	1	Metal film resistor
R36	5322 111 20317	1	MΩ	0.125	1	Carbon resistor
R37	5322 116 50808	796	Ω	0.1	0.5	Metal film resistor
R46	5322 111 30304	150	kΩ	0.1	5	Carbon resistor
R47	5322 111 20147	800	kΩ	0.25	1	Carbon resistor
R48	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R49	4822 111 30394	2.2	MΩ	0.125	10	Carbon resistor
R51	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R52	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R53	4822 111 30263	3.3	kΩ	0.1	5	Carbon resistor
R54	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R56	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R57	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R58	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R59	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R61	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R62	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R63	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R64	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R66	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R67	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R68	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R69	5322 111 30354	12	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R71	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R72	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R73	5322 111 30378	200	Ω	0.1	5	Carbon resistor
R74	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R75	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R76	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R77	5322 116 51065	133	Ω	0.1	0.25	Metal film resistor
R78	5322 116 51066	237	Ω	0.1	0.25	Metal film resistor
R79	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R81	5322 111 30378	200	Ω	0.1	5	Carbon resistor
R82	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R83	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R84	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R86	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R87	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R88	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R89	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R91	5322 116 50679	237	Ω	0.25	1	Metal film resistor
R92	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R93	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R94	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R96	5322 111 30355	20	Ω	0.1	5	Carbon resistor
R97	5322 116 50983	22.1	Ω	0.25	1	Metal film resistor
R98	5322 116 50788	332	Ω	0.1	0.25	Metal film resistor
R99	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R101	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R102	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R103	4822 111 30397	240	Ω	0.1	5	Carbon resistor
R106	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R107	4822 111 30303	8.2	kΩ	0.1	5	Carbon resistor
R109	5322 100 10075	100	Ω	0.1	20	Potentiometer
R110	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R111	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R112	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R117	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R118	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R119	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R120	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R121	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R122	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R124	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R131	4822 111 30271	820	Ω	0.1	5	Carbon resistor
R132	4822 100 10038	470	Ω	0.1	20	Potentiometer
R133	5322 116 50752	1.5	kΩ	0.1	0.25	Metal film resistor
R134	5322 116 50847	499	Ω	0.1	0.25	Metal film resistor
R136	5322 116 51067	249	Ω	0.1	0.25	Metal film resistor
R137	5322 116 50751	150	Ω	0.1	0.25	Metal film resistor
R138	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R139	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R141	5322 111 20147	800	kΩ	0.25	1	Carbon resistor

Item	Code number	Value		Watt	%	Description
R142	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R143	5322 101 20241	1	kΩ	0.1	20	Potentiometer
R144	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R146	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R148	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R149	5322 116 50482	33.2	kΩ	0.25	1	Metal film resistor
R151	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R152	4822 111 30395	4.7	MΩ	0.125	10	Carbon resistor
R162	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R164	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R226	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R227	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R228	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R229	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R231	4822 111 20332	920	kΩ	0.25	1	Carbon resistor
R232	5322 116 50821	88.7	kΩ	0.25	1	Metal film resistor
R233	4822 111 20333	992	kΩ	0.25	1	Carbon resistor
R234	5322 116 50914	8.06	kΩ	0.25	1	Metal film resistor
R236	5322 111 20317	1	MΩ	0.125	1	Carbon resistor
R237	5322 116 50808	796	Ω	0.1	0.5	Metal film resistor
R246	5322 111 30304	150	kΩ	0.1	5	Carbon resistor
R247	5322 111 20147	800	kΩ	0.25	1	Carbon resistor
R248	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R249	4822 111 30394	2.2	MΩ	0.125	10	Carbon resistor
R251	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R252	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R253	4822 111 30263	3.3	kΩ	0.1	5	Carbon resistor
R254	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R256	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R257	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R258	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R259	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R261	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R262	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R263	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R264	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R266	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R267	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R268	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R269	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R271	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R272	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R273	5322 111 30378	200	Ω	0.1	5	Carbon resistor
R274	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R275	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R276	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R277	5322 116 51065	133	Ω	0.1	0.25	Metal film resistor
R278	5322 116 51066	237	Ω	0.1	0.25	Metal film resistor
R279	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R281	5322 111 30378	200	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R282	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R283	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R284	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R286	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R287	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R288	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R289	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R291	5322 116 50679	237	Ω	0.25	1	Metal film resistor
R292	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R293	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R294	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R296	5322 111 30355	20	Ω	0.1	5	Carbon resistor
R297	5322 116 50983	22.1	Ω	0.25	1	Metal film resistor
R298	5322 116 50788	332	Ω	0.1	0.25	Metal film resistor
R299	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R301	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R302	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R303	4822 111 30397	240	Ω	0.1	5	Carbon resistor
R306	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R307	4822 111 30303	8.2	kΩ	0.1	5	Carbon resistor
R309	5322 100 10075	100	Ω	0.1	20	Potentiometer
R310	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R311	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R312	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R317	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R318	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R319	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R320	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R321	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R322	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R324	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R331	4822 111 30271	820	Ω	0.1	5	Carbon resistor
R332	4822 100 10038	470	Ω	0.1	20	Potentiometer
R333	5322 116 50752	1.5	kΩ	0.1	0.25	Metal film resistor
R334	5322 116 50847	499	Ω	0.1	0.25	Metal film resistor
R336	5322 116 51067	249	Ω	0.1	0.25	Metal film resistor
R337	5322 116 50751	150	Ω	0.1	0.25	Metal film resistor
R338	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R339	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R341	5322 111 20147	800	kΩ	0.25	1	Carbon resistor
R342	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R343	5322 101 20241	1	kΩ	0.1	20	Potentiometer
R344	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R346	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R348	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R349	5322 116 50482	33.2	kΩ	0.25	1	Metal film resistor
R351	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R352	4822 111 30395	4.7	MΩ	0.125	10	Carbon resistor
R362	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R364	4822 111 30348	27	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R401	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R402	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R403	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R404	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R406	5322 111 30289	56	kΩ	0.1	5	Carbon resistor
R407	5322 100 10079	47	kΩ	0.1	20	Potentiometer
R408	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R411	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R416	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R417	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R418	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R424	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R426	4822 110 60109	1.2	kΩ	0.125	5	Carbon resistor
R428	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R429	4822 100 10038	470	Ω	0.1	20	Potentiometer
R430	4822 100 10035	10	kΩ	0.1	20	Potentiometer
R431	4822 100 10029	2.2	kΩ	0.1	20	Potentiometer
R432	4822 111 30279	33	kΩ	0.1	5	Carbon resistor
R434	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R435	4822 111 30276	18	kΩ	0.1	5	Carbon resistor
R437	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R438	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R439	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R441	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R442	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R443	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R444	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R446	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R447	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R448	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R449	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R450	5322 116 50442	48.7	kΩ	0.25	1	Metal film resistor
R453	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R454	5322 116 50414	2.87	kΩ	0.25	1	Metal film resistor
R455	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R456	5322 116 50664	2.05	kΩ	0.25	1	Metal film resistor
R457	5322 116 50554	750	Ω	0.25	1	Metal film resistor
R458	5322 116 50571	715	Ω	0.25	1	Metal film resistor
R459	5322 116 50664	2.05	kΩ	0.25	1	Metal film resistor
R461	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R462	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R463	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R465	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R466	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R467	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R468	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R481	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R482	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R483	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R484	4822 111 30399	33	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R486	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R487	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R525	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R601	4822 111 30398	300	Ω	0.125	5	Carbon resistor
R602	5322 100 10036	4.7	kΩ	0.1	20	Potentiometer
R603	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R604	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R605	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R606	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R607	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R608	4822 111 30398	300	Ω	0.1	5	Carbon resistor
R609	5322 100 10075	100	Ω	0.1	20	Potentiometer
R610	5322 111 30291	68	kΩ	0.1	5	Carbon resistor
R611	4822 111 30267	1.5	kΩ	0.1	5	Carbon resistor
R612	4822 111 30398	300	Ω	0.1	5	Carbon resistor
R613	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R614	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R615	5322 116 50554	750	Ω	0.25	5	Carbon resistor
R616	5322 100 10036	4.7	kΩ	0.1	20	Potentiometer
R617	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R620	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R622	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R623	4822 110 50116	2.2	kΩ	0.25	5	Carbon resistor
R628	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R632	4822 110 50116	2.2	kΩ	0.25	5	Carbon resistor
R634	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R701	4822 101 20426	470	Ω	0.1	20	Potentiometer
R704	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R706	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R707	4822 111 30402	7.5	kΩ	0.1	5	Carbon resistor
R708	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R709	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R712	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R713	5322 116 30079	1.5	kΩ	0.5	20	NTC-resistor
R717	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R721	4822 111 30263	3.3	kΩ	0.1	5	Carbon resistor
R722	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R724	5322 111 30261	560	kΩ	0.1	10	Carbon resistor
R726	5322 111 30259	470	kΩ	0.1	10	Carbon resistor
R727	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R728	5322 111 30296	100	kΩ	0.1	10	Carbon resistor
R729	5322 111 30342	10	MΩ	0.125	10	Carbon resistor
R731	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R732	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R733	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R734	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R736	4822 111 30352	82	Ω	0.1	5	Carbon resistor
R739	4822 111 30173	15	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R741	4822 111 30173	15	Ω	0.1	5	Carbon resistor
R743	4822 101 20426	470	Ω	0.1	20	Potentiometer
R746	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R747	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R748	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R749	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R751	5322 111 30277	22	kΩ	0.1	5	Carbon resistor
R752	5322 101 20243	4.7	kΩ	0.1	20	Potentiometer
R753	5322 111 30277	22	kΩ	0.1	5	Carbon resistor
R754	4822 111 30274	12	kΩ	0.1	5	Carbon resistor
R756	4822 111 30274	12	kΩ	0.1	5	Carbon resistor
R757	4822 111 30274	12	kΩ	0.1	5	Carbon resistor
R761	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R762	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R763	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R764	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R766	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R767	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R768	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R769	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R772	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R773	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R774	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R801	4822 111 30303	8.2	kΩ	0.1	5	Carbon resistor
R802	4822 111 30323	270	Ω	0.1	5	Carbon resistor
R803	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R804	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R806	4822 111 30352	82	Ω	0.1	5	Carbon resistor
R807	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R808	4822 111 30329	390	Ω	0.1	5	Carbon resistor
R811	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R812	4822 111 30267	1.5	kΩ	0.1	5	Carbon resistor
R813	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R814	4822 111 30323	270	Ω	0.1	5	Carbon resistor
R817	4822 111 30323	270	Ω	0.1	5	Carbon resistor
R818	4822 111 30331	470	Ω	0.1	5	Carbon resistor
R821	5322 111 30302	220	kΩ	0.1	5	Carbon resistor
R822	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R823	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R824	5322 111 30275	15	kΩ	0.1	5	Carbon resistor
R826	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R827	5322 111 30275	15	kΩ	0.1	5	Carbon resistor
R828	5322 111 30278	27	kΩ	0.1	5	Carbon resistor
R830	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R831	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R832	5322 111 30276	18	kΩ	0.1	5	Carbon resistor
R833	4822 100 10035	10	kΩ	0.1	20	Potentiometer
R836	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R837	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R838	5322 111 34094	620	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R839	5322 111 30272	680	Ω	0.1	5	Carbon resistor
R841	4822 111 30329	390	Ω	0.1	5	Carbon resistor
R843	5322 111 30258	390	kΩ	0.1	10	Carbon resistor
R844	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R846	4822 111 30272	680	Ω	0.1	5	Carbon resistor
R847	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R848	5322 111 30277	22	kΩ	0.1	5	Carbon resistor
R849	4822 110 50198	2.7	MΩ	0.125	10	Carbon resistor
R851	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R853	5322 111 30359	1.3	kΩ	0.1	5	Carbon resistor
R854	5322 111 30278	27	kΩ	0.1	5	Carbon resistor
R856	5322 111 30270	18	kΩ	0.1	5	Carbon resistor
R861	5322 110 30173	300	kΩ	0.25	1	Carbon resistor
R862	5322 116 50594	120	kΩ	0.125	1	Carbon resistor
R863	5322 116 50626	60.4	kΩ	0.125	0.5	Metal film resistor
R864	5322 116 51068	33.2	kΩ	0.125	0.5	Metal film resistor
R866	5322 110 30189	1.2	MΩ	0.25	1	Carbon resistor
R867	5322 111 20144	600	kΩ	0.25	1	Carbon resistor
R868	5322 116 50594	120	kΩ	0.125	1	Carbon resistor
R869	5322 116 50626	60.4	kΩ	0.125	0.5	Metal film resistor
R871	4822 111 40201	3	MΩ	0.25	1	Carbon resistor
R873	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R874	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R876	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R877	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R902	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R903	5322 111 30256	270	kΩ	0.1	5	Carbon resistor
R904	5322 116 51071	931	Ω	0.1	0.5	Metal film resistor
R906	5322 111 30276	18	kΩ	0.1	5	Carbon resistor
R907	5322 111 30133	9.1	kΩ	0.1	5	Carbon resistor
R908	5322 111 30276	18	kΩ	0.1	5	Carbon resistor
R909	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R916	4822 110 60136	12	kΩ	0.125	2	Carbon resistor
R917	5322 116 50176	6.49	kΩ	0.1	0.5	Metal film resistor
R918	4822 110 60136	12	kΩ	0.125	2	Carbon resistor
R922	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R924	5322 116 50556	4.42	kΩ	0.25	1	Metal film resistor
R926	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R927	4822 110 60091	240	Ω	0.125	2	Carbon resistor
R928	4822 110 60091	240	Ω	0.125	2	Carbon resistor
R929	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R931	5322 116 50556	4.42	kΩ	0.25	1	Metal film resistor
R933	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R934	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R937	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R938	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R941	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R943	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R944	4822 100 10035	10	kΩ	0.1	20	Potentiometer
R946	4822 100 10029	2.2	kΩ	0.1	20	Potentiometer

Item	Code number	Value		Watt	%	Description
R947	4822 111 30314	6.8	kΩ	0.1	5	Carbon resistor
R948	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R951	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R954	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R959	5322 100 10036	4.7	kΩ	0.1	20	Potentiometer
R962	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R966	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R971	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R974	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R978	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R979	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R981	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R982	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R983	4822 110 30115	2	kΩ	0.5	5	Carbon resistor
R984	4822 110 30115	2	kΩ	0.5	5	Carbon resistor
R1001	5322 101 20243	4.7	kΩ	0.1	20	Potentiometer
R1021	4822 101 20425	10	kΩ	0.1	20	Potentiometer
R1024	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R1035	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R1036	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R1041	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R1044	5322 101 20279	47	kΩ	0.1	20	Potentiometer
R1047	4822 101 20239	22	kΩ	0.1	20	Potentiometer
R1048	4822 103 20091	4.7	kΩ	3	5	Potentiometer
R1050	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R1103	4822 115 40197	4.7	Ω	16	5	Wire wound resistor
R1108	5322 100 10037	1	kΩ	0.1	20	Potentiometer
R1114	5322 100 10037	1	kΩ	0.1	20	Potentiometer
R1200	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R1205	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R1207	5322 111 50345	8.2	MΩ	1	5	Carbon resistor
R1401	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R1402	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R1403	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1404	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1406	5322 111 30289	56	kΩ	0.1	5	Carbon resistor
R1407	5322 100 10079	47	kΩ	0.1	20	Potentiometer
R1408	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1411	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R1416	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R1417	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1418	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1424	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1428	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R1429	4822 100 10038	470	Ω	0.1	20	Potentiometer
R1430	4822 100 10035	10	kΩ	0.1	20	Potentiometer
R1431	4822 100 10029	2.2	kΩ	0.1	20	Potentiometer
R1432	4822 111 30279	33	kΩ	0.1	5	Carbon resistor
R1434	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1435	4822 111 30276	18	kΩ	0.1	5	Carbon resistor

Item	Code number	Value	Watt	%	Description
R1437	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1438	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1439	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1441	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1442	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1443	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1444	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1446	4822 111 30399	33 Ω	0.1	5	Carbon resistor

C. DIODES

Type	Ordering code	Item
AAZ15	4822 130 30229	GR1003
BA148	4822 130 30256	GR1201...GR1209
BAX13	4822 130 40182	GR35, GR235, GR403, GR404, GR406, GR407, GR408, GR409, GR411, GR501, GR502, GR504, GR506, GR508, GR509, GR511, GR601, GR602, GR701, GR702, GR804, GR806, GR808, GR901, GR902, GR906, GR907, GR908, GR909, GR911, GR912, GR913, GR914, GR1004, GR1406, GR1407, GR1408, GR1409.
BAX16	4822 130 30273	GR1001
BAX17	5322 130 30605	GR26, GR27, GR28, GR226, GR227, GR228
BY176	4822 130 30588	GR1211, GR1212, GR1213, GR1214
BZX61/C33	4822 130 30786	GR1006
BZX61/C47	5322 130 30565	GR916, GR917
BZY88/C3V3	5322 130 30392	GR29, GR229
BZY88/C3V9	4822 130 30411	GR30, GR34, GR230, GR234
BZY88/C4V7	4822 130 30264	GR503
BZY88/C5V6	4822 130 30193	GR801, GR1106
BZY88/C6V8	4822 130 30079	GR1107
BZY88/C8V2	4822 130 30294	GR32, GR33, GR232, GR233
BZY88/C12	4822 130 30346	GR507, GR703
BZY88/C18	4822 130 30304	GR31, GR231
E1120	5322 130 30541	GR1101, GR1103
E1220	5322 130 30542	GR1102, GR1104
OF162	4822 130 30266	GR807

D. TRANSISTORS

Type	Ordering code	Item
BC107	4822 130 40357	TS38, TS42, TS238, TS242, TS406, TS407, TS408, TS409, TS411, TS412, TS501, TS504, TS606, TS607, TS808, TS811, TS901, TS902, TS1004, TS1006, TS1008, TS1106, TS1107, TS1406, TS1407, TS1408, TS1409, TS1411
BC109C	4822 130 40144	TS806, TS807, TS812
BCY70	5322 130 40324	TS506, TS809, TS911
BCY72	5322 130 40486	TS1001, TS1003
BDY38	4822 130 40524	TS1102
BDY60	4822 130 40852	TS1201, TS1202
BF179	5322 130 40661	TS916, TS917
BFW44	5322 130 40672	TS914, TS918
BFY52	5322 130 40462	TS1103, TS1104
BFY90	5322 130 40493	TS28, TS29, TS36, TS37, TS39, TS41, TS228, TS229, TS236, TS237, TS239, TS241, TS703, TS801, TS802, TS803
BSX20	5322 130 40417	TS502, TS503, TS507, TS706, TS707, TS709, TS711, TS712, TS1002, TS1108
BSX21	4822 130 40312	TS1002
BSY39A	5322 130 40632	TS804
FW5324	5322 130 40142	TS31, TS32, TS33, TS34, TS231, TS232, TS233, TS234, TS413, TS414, TS416, TS417, TS601, TS602, TS603, TS604, TS608, TS702, TS903, TS904, TS906, TS907, TS908, TS909, TS912, TS913, TS1007.

E. SELECTED TRANSISTOR PAIRS

Type	Ordering code	Item
BFW11	5322 130 44031	TS26-1 & 2, TS226-1 & 2, TS704-1 & 2
BC107	5322 130 44029	TS401-1 & 2, TS1401-1 & 2
BC109C	5322 130 40662	TS43-1 & 2, TS243-1 & 2
BFY90	5322 130 44035	TS403-1 & 2, TS1403-1 & 2

F. MISCELLANEOUS PARTS

Item	Code number	Description
B1001	5322 131 20037	C.r.t. D14-120GH
B1002	5322 131 90024	Neon stabilizer ZA1004
B26	4822 134 20016	Neon stabilizer GL8
B226	4822 134 20016	Neon stabilizer GL8
LA1	5322 134 40054	Lamp 6828
LA2	5322 134 40054	Lamp 6828
LA3	5322 134 40212	Lamp 6226
VL1	4822 253 30021	Fuse, 1 A delayed action
	4822 253 30025	Fuse, 2 A delayed action
VL1101	4822 252 20001	Thermal fuse
L501	5322 158 10243	Coil 100 μH
L1001	5322 157 50708	Trace rotation coil
L1201	5322 158 20342	Coil
L1202	4822 157 50308	Coil
L1203	4822 157 50308	Coil
T401	5322 526 14001	Ferroxcube ring
T402	5322 526 14001	Ferroxcube ring
T501	5322 158 10361	Blocking transformer
T1001	5322 158 10359	Blanking transformer
T1101	5322 146 20469	Mains transformer
T1102	5322 158 14006	Suppression transformer
T1103	5322 158 14006	Suppression transformer
T1201	5322 142 60133	Converter transformer
T1401	5322 526 14001	Ferroxcube ring
T1402	5322 526 14001	Ferroxcube ring
RE601	5322 280 20042	Relay contacts
	5322 157 50093	Relay coil

G. LIMIT VALUES OF SELECT-IN-TEST COMPONENTS

Item	Power rating	Limit values
R108	0.1 W	39 Ω ... 82 Ω
R150	0.125 W	1 kΩ ... 5.6 kΩ
R308	0.1 W	39 Ω ... 82 Ω
R350	0.125 W	1 kΩ ... 5.6 kΩ
R1013	0.5 W	220 kΩ ... 1.2 MΩ
R1018	0.125 W	4.7 kΩ ... 47 kΩ
R1019	0.125 W	10 kΩ ... 39 kΩ
R1136	0.25 W	100 kΩ ... 330 kΩ
R1138	0.25 W	8.2 kΩ ... 15 kΩ

QUALITY REPORTING

CODING SYSTEM FOR FAILURE DESCRIPTION

The following information is meant for Philips service workshops only and serves as a guide for exact reporting of service repairs and maintenance routines on the workshop charts.
For full details reference is made to Information G1 (Introduction) and Information Cd 689 (Specific information for Test and Measuring Instruments).

LOCATION

□□□

Unit number
e.g. 000A or 0001 (for unit A or 1; not 00UA or 00U1)

or: Type number of an accessory (only if delivered with the equipment)
e.g. 9051 or 9532 (for PM 9051 or PM 9532)

or: Unknown/Not applicable
0000

CATEGORY

□

0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

COMPONENT/SEQUENCE NUMBER

□□□□

Enter the identification as used in the circuit diagram, e.g.:

GR1003	Diode GR1003
TS0023	Transistor TS23
IC0101	Integrated circuit IC101
R0....	Resistor, potentiometer
C0....	Capacitor, variable capacitor
B0....	Tube, valve
LA....	Lamp
VL....	Fuse
SK....	Switch
BU....	Connector, socket, terminal
T0....	Transformer
L0....	Coil
X0....	Crystal
CB....	Circuit block
RE....	Relay
ME....	Meter, indicator
BA....	Battery
TR....	Chopper

Parts not identified in the circuit diagram:

990000	Unknown/Not applicable
990001	Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)
990002	Knob (incl. dial knob, cap, etc.)
990003	Probe (only if attached to instrument)
990004	Leads and associated plugs
990005	Holder (valve, transistor, fuse, board, etc.)
990006	Complete unit (p.w. board, h.t. unit, etc.)
990007	Accessory (only those without type number)
990008	Documentation (manual, supplement, etc.)
990009	Foreign object
990099	Miscellaneous

PHILIPS

SERVICE

Electron optics / Nuclear and electrochemical equipment / X-Ray analysis / Cryogenic equipment / Test and measuring equipment / Process instrumentation / Industrial Data Processing Systems / Weighing / Welding / Numerical Control / Textile equipment

industrial equipment division

1-3-1972 PM 3210/02/03 Cd 725

TEST AND MEASURING INSTRUMENTS

1. MODIFICATIONS INTRODUCED INTO PM 3210/02 and /03 MODELS

1.1. General

A number of minor circuit modifications have been introduced, which appear from the enclosed circuit diagrams, circuit board drawings and parts list.

1.2. Mains transformer

As from PM 3210/03, the mains transformer and the voltage adapter have been changed; see enclosed circuit diagram Fig. 71 for /03 model.
The new transformer unit, including mains transformer, voltage adapter, rectifier diodes and capacitor C1100, can also be used for previous models. Therefore, the mains transformer of the /01 and /02 models, 5322 146 20469, is obsolete and replaced by mains transformer unit 5322 146 24024 for all models. Also voltage adapter 5322 272 10003 is obsolete for all models PM 3210.

1.3. H.T. Unit 6

If the H.T. unit is to be replaced by a unit supplied by the Concern Service Department, C1113 has to be removed. C1113, a 100 μF electrolytic capacitor which is NOT present in all instruments, is located on the mounting plate of transistor TS1102 on the rear panel of the instrument, over the output sockets.

2. MANUAL FOR PM 3210/02 AND /03 MODELS

For these instruments manual 9499 440 07611 of the PM 3210/01 model can be used, together with this modification sheet. The relevant circuit board drawings and circuit diagrams should be replaced by the ones enclosed with this modification sheet.

[illegible] INSTRUMENTS INC.
A NORTH AMERICAN PHILIPS COMPANY
224 DUFFY AVENUE
HICKSVILLE, NEW YORK 11802

3. ERRATA IN MANUAL 9499 440 07611

3.1. Chapter II. section Y AXIS
The drift specification should read:

Maximum drift at maximum gain	Typical values at constant ambient temperature (measurements began half an hour after switching in) Short term over 1 minute 0.5 cm Long term over 1 hour 0.5 cm
Temperature drift	Typical values at 1 mV/cm : 0.1 cm/^{o}C at 10 mV/cm : 0.01 cm/^{o}C

3.2. Chapter VII. section Preliminary Settings of the Controls:
- Set SHIFT (R13/R14)... should read Set POSITION (R14/R15)...
- Set AMPL. (R8/R9) and TIME/cm (R13)... should read Set AMPL. (R8/R13) and TIME/cm (R4)...

Section General Check of the same chapter:
- AC-0-DC (SK9)... should read AC-0-DC (SK11)...

3.3. Chapter XIII. section Selected Transistor Pairs:

TS401 - 1 & 2	should read TS401, TS402
TS1401 - 1 & 2	should read TS1401, TS1402
TS403 - 1 & 2	should read TS403, TS404
TS1403 - 1 & 2	should read TS1403, TS1404

3.4. The connection numbers of transformer T1201 as indicated in Fig. 68 of the manual are wrong. The correct numbers are given at the transformer outline in circuit diagram Fig. 69 and in the enclosed Fig. 68.

- Set potentiometers POSITION R7 & R15 to the centre position.
- Set mode selector SK10 to position Y_B.
- Set switch Y_A - Y_B - EXT SK4 to position Y_B.
- Pull the switch of potentiometer LEVEL R1 to AUTO.
- If the time-base generator works now, the trigger circuit is faulty:
  Check the stability setting and the potentials of the various points in the trigger circuit.
- If the time-base generator does not work yet, connect the collector of transistor TS804 to earth and check that the potentials of the various points in the time-base generator meet the values stated in the circuit diagram for the starting point of the time-base sweep.

C. NOTES

In case of a defect it is always possible to apply to the world wide PHILIPS Service Organisation.
When the instrument is to be sent to a PHILIPS Service workshop for repair, the following points should be observed:

- Attach a label with your name and address to the instrument.
- Give a complete description of the faults found.
- Use the original packing or, if this is no longer available, carefully pack the instrument in a wooden crate or box.
- Send the instrument to the address obtained after consultation with the local PHILIPS Organisation.

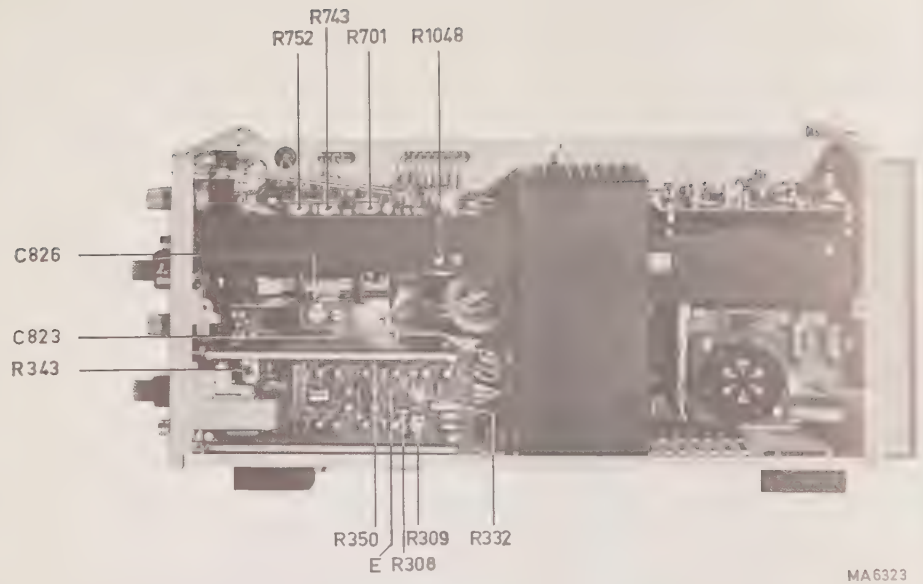


Fig. 51. Checking and adjusting: right-hand side view

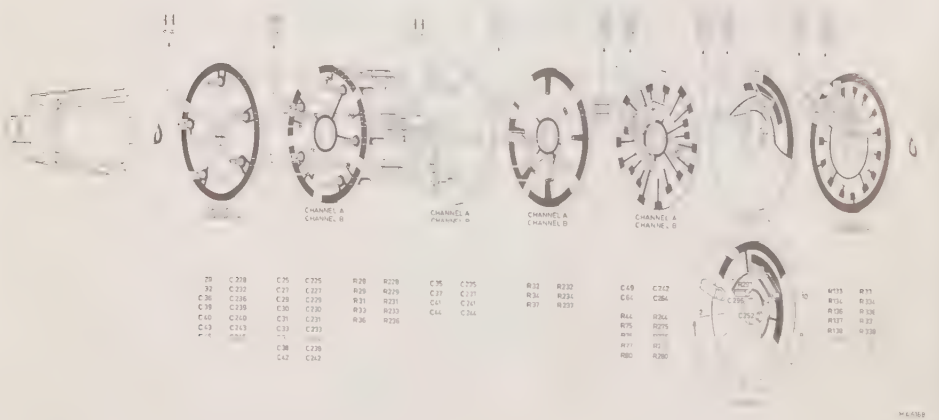


Fig. 53. Attenuator switch

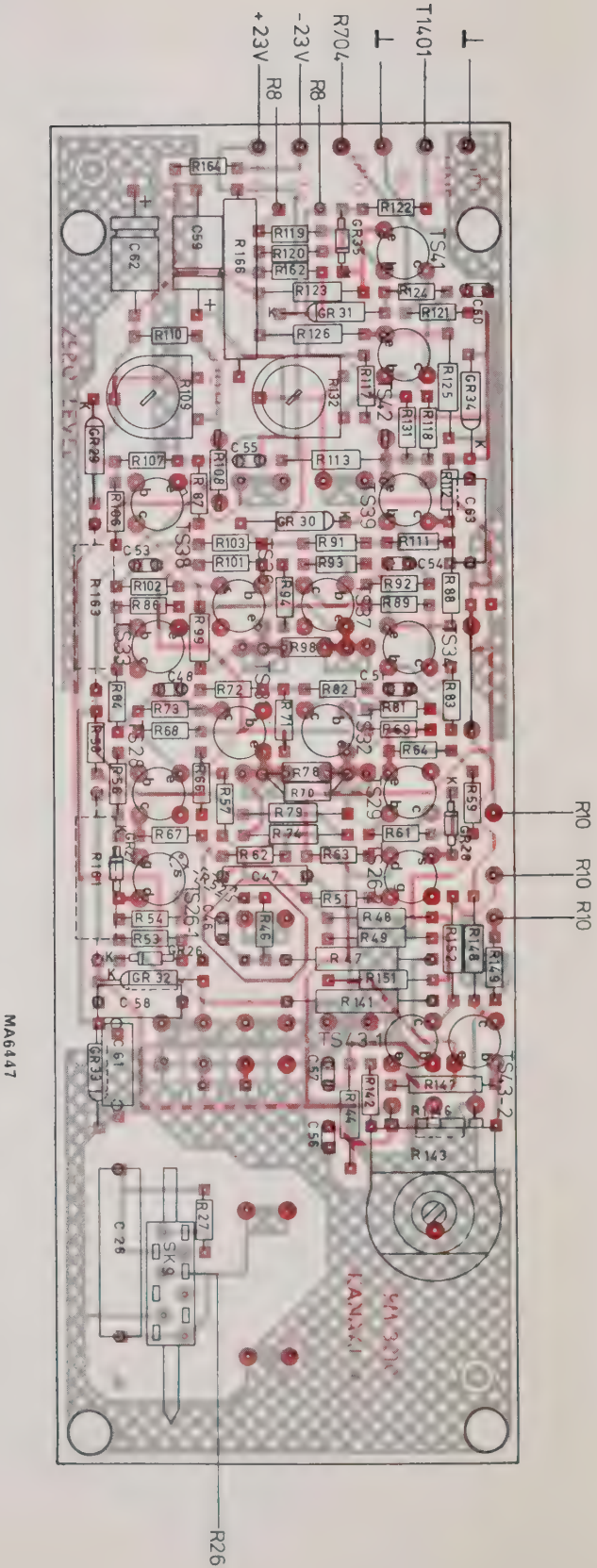


Fig. 54. Unit 1. Channel A vertical pre-amplifier

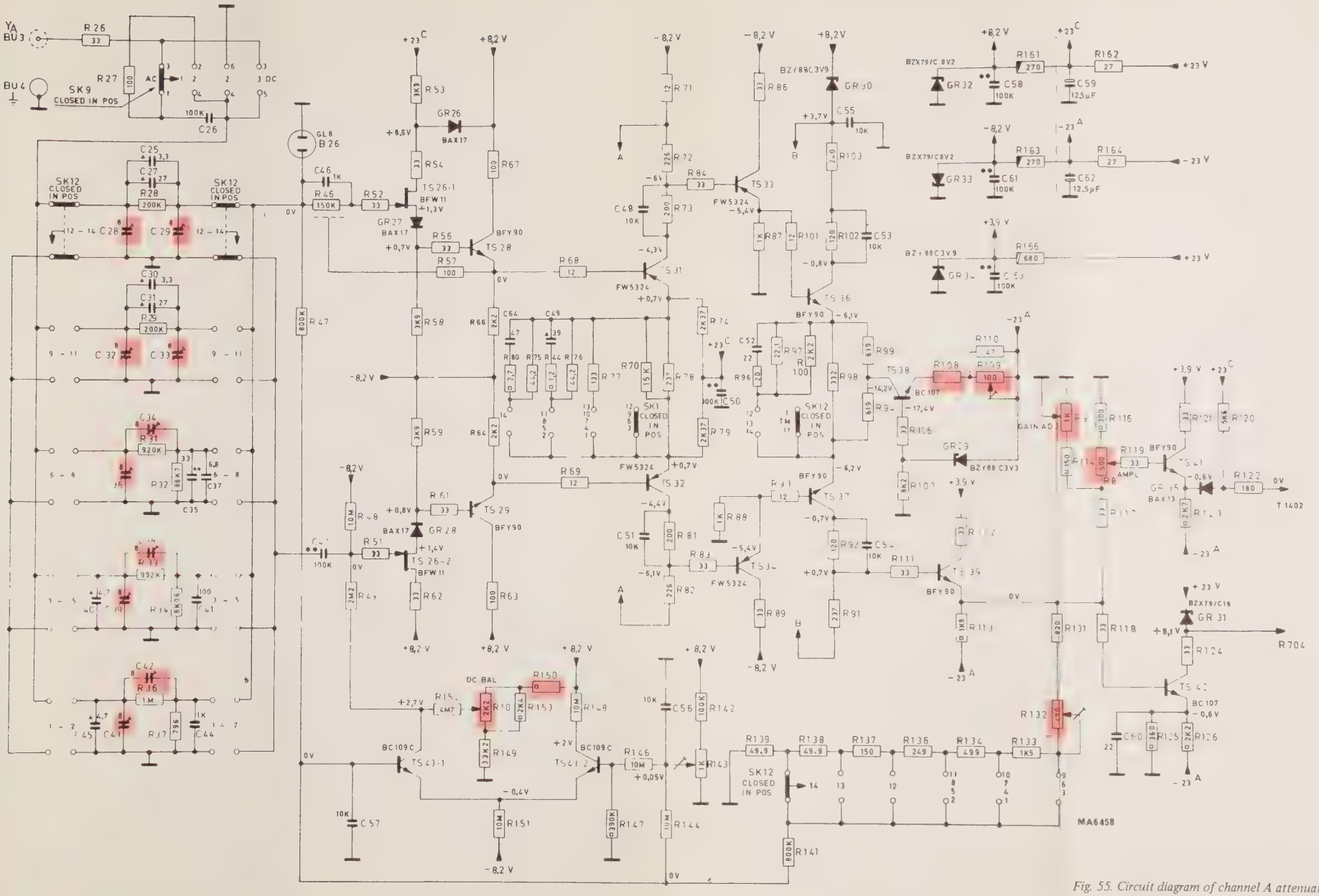


Fig. 55. Circuit diagram of channel A attenuator and pre-amplifier

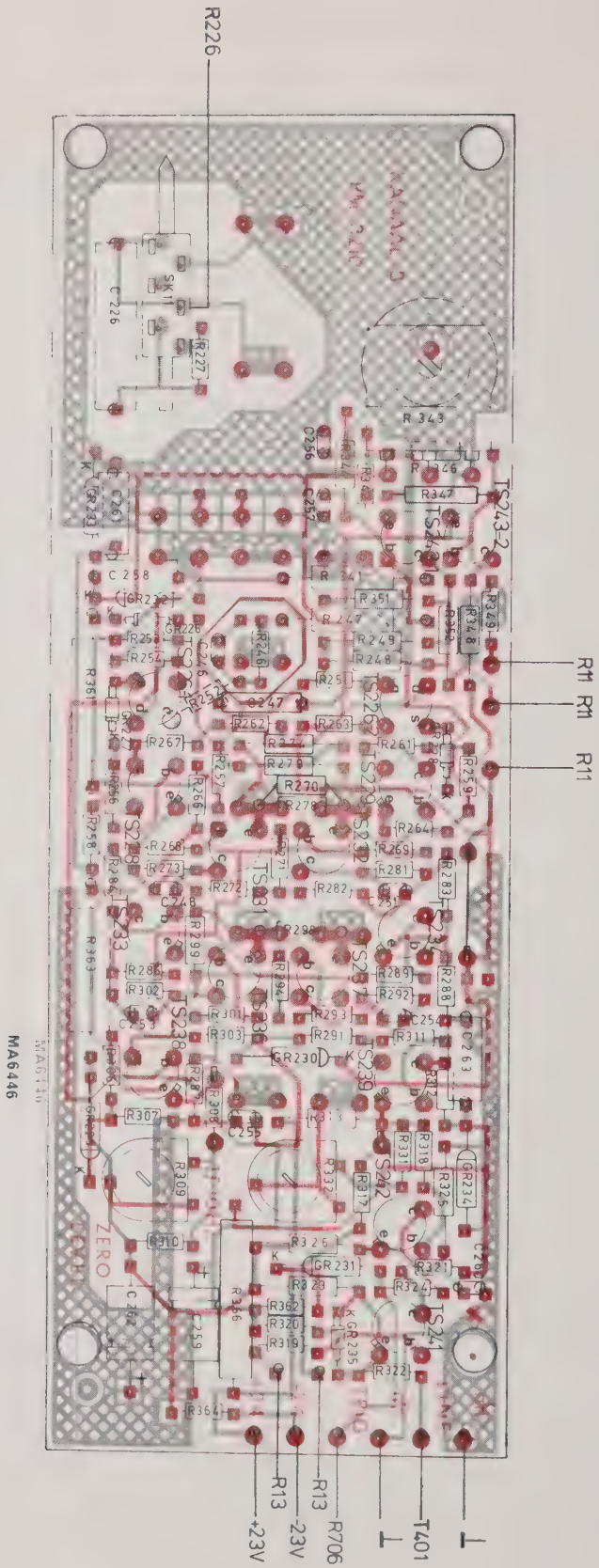


Fig. 56. Unit 2. Channel B vertical pre-amplifier

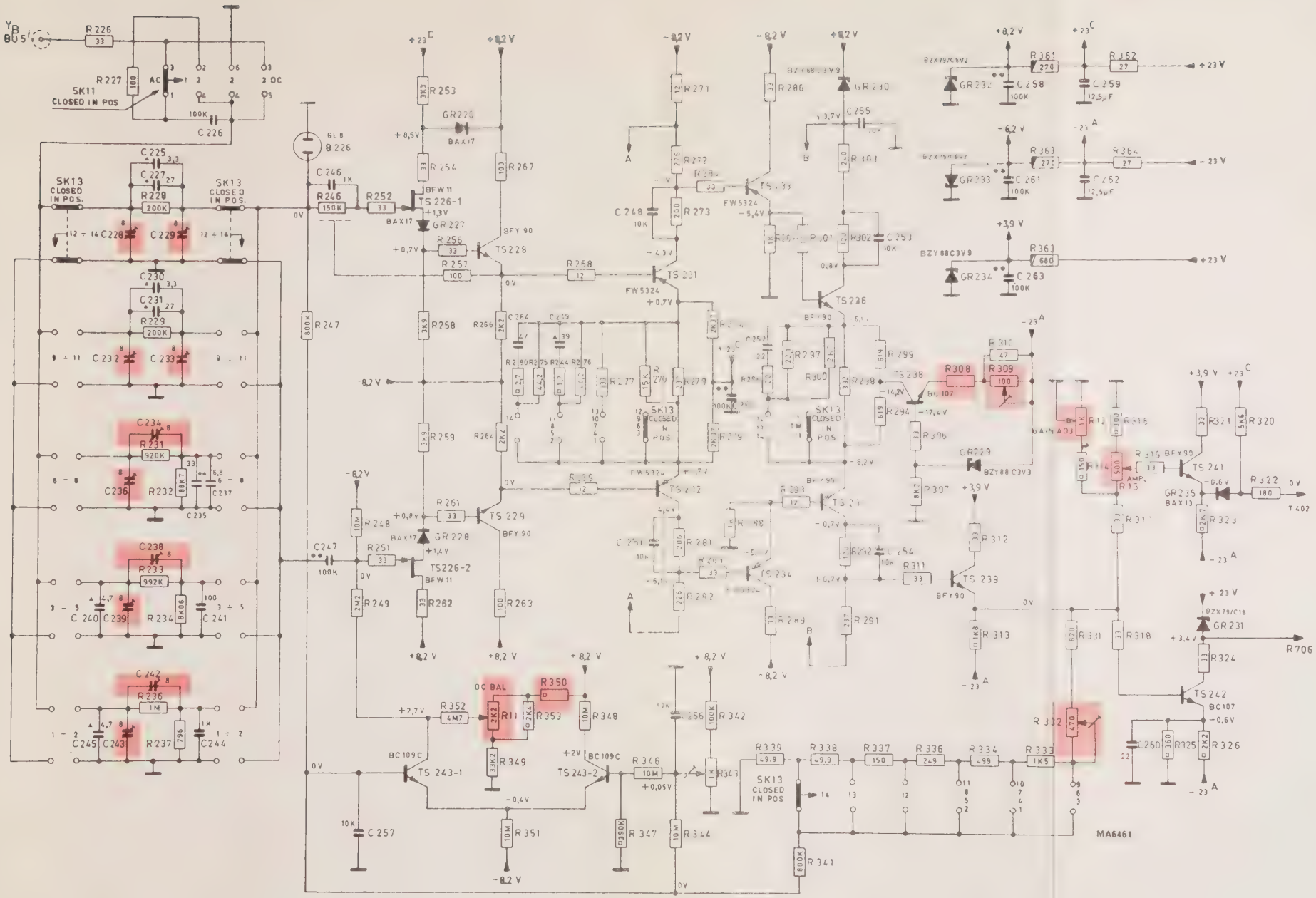


Fig. 57. Circuit diagram of channel B attenuator and pre-amplifier

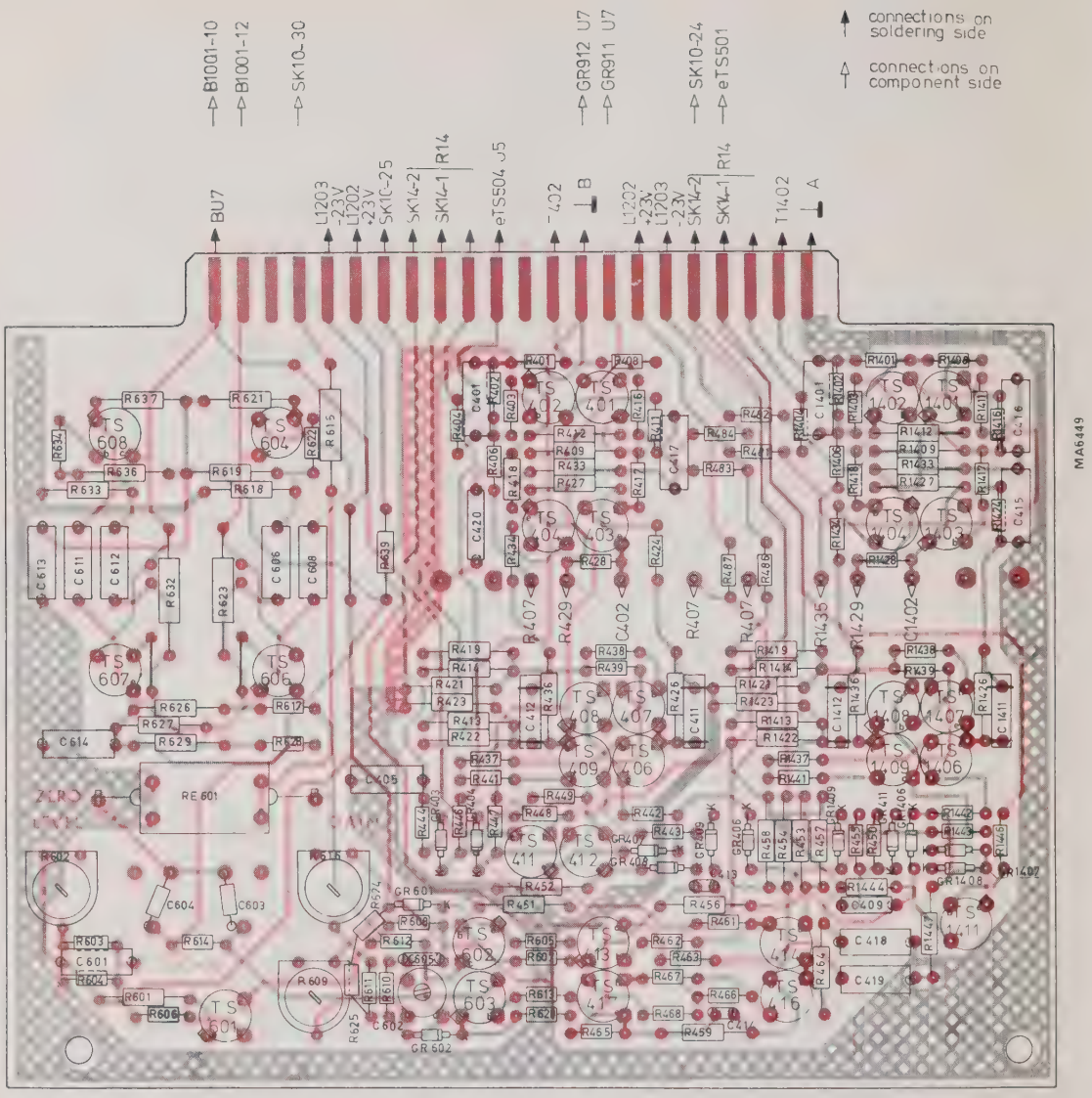


Fig. 58. Unit 4. Vertical amplifier

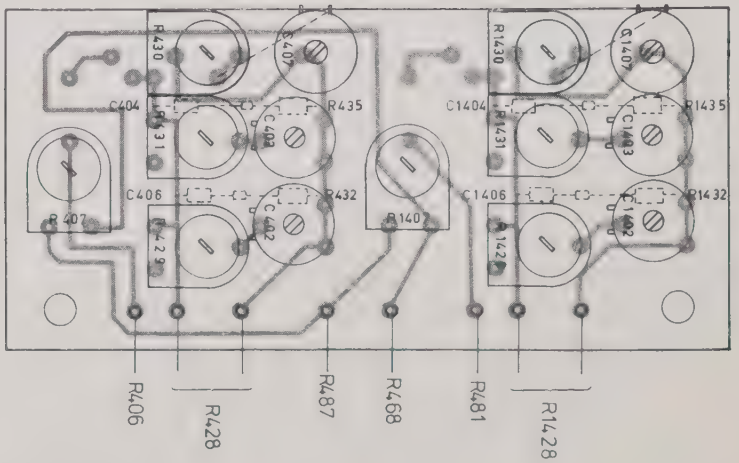


Fig. 58A. Unit 402. Adjusting unit

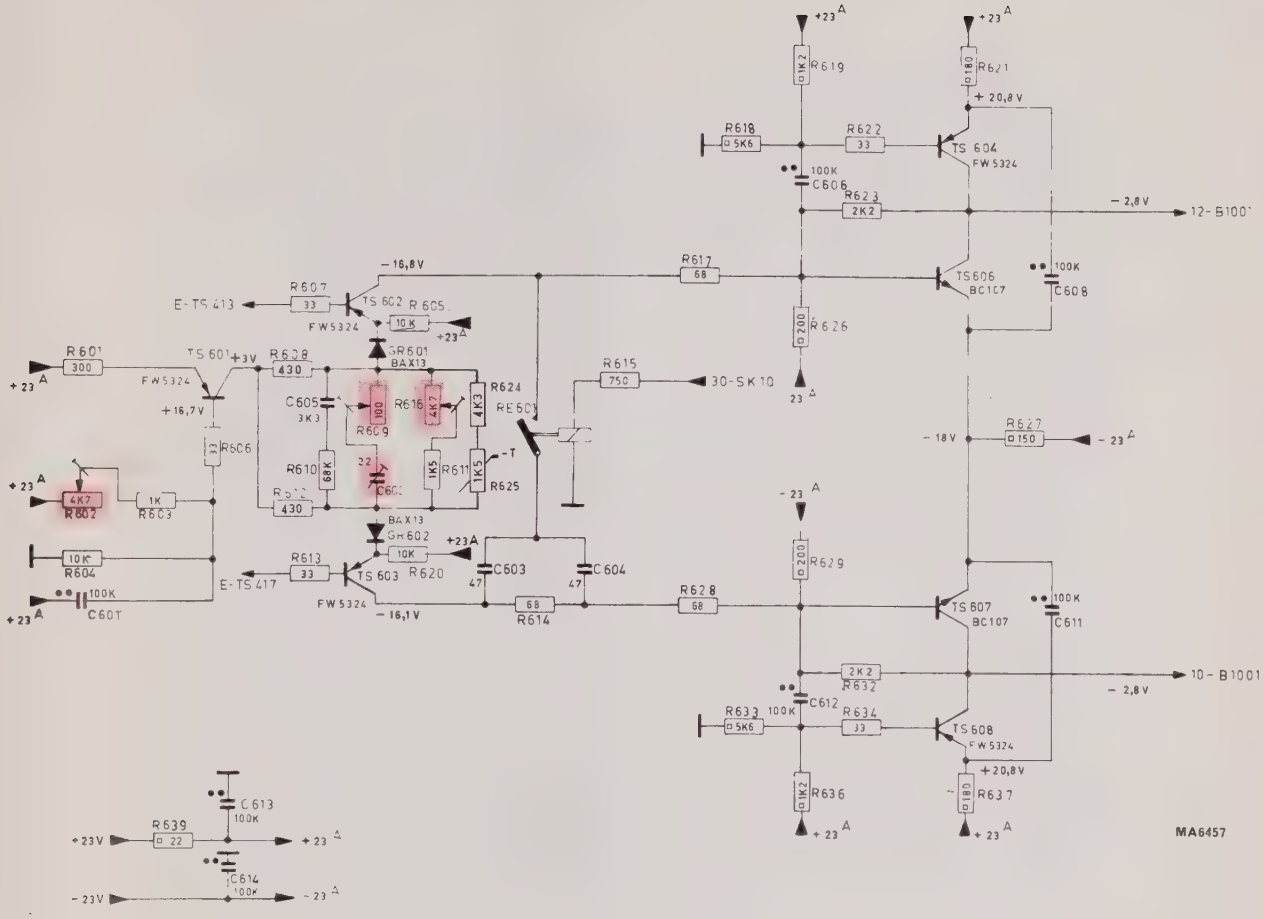


Fig. 60. Circuit diagram of the vertical output amplifier

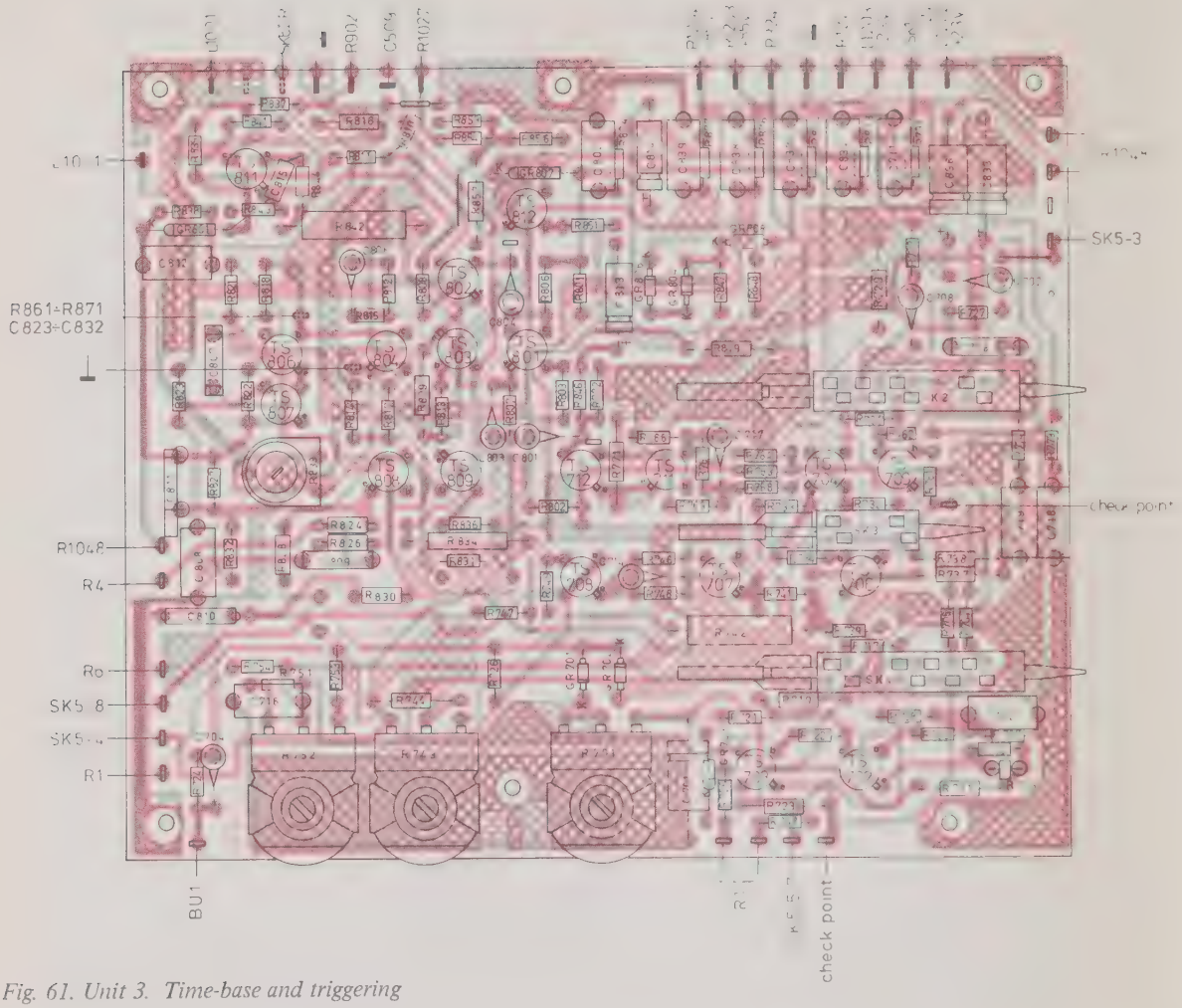


Fig. 61. Unit 3. Time-base and triggering

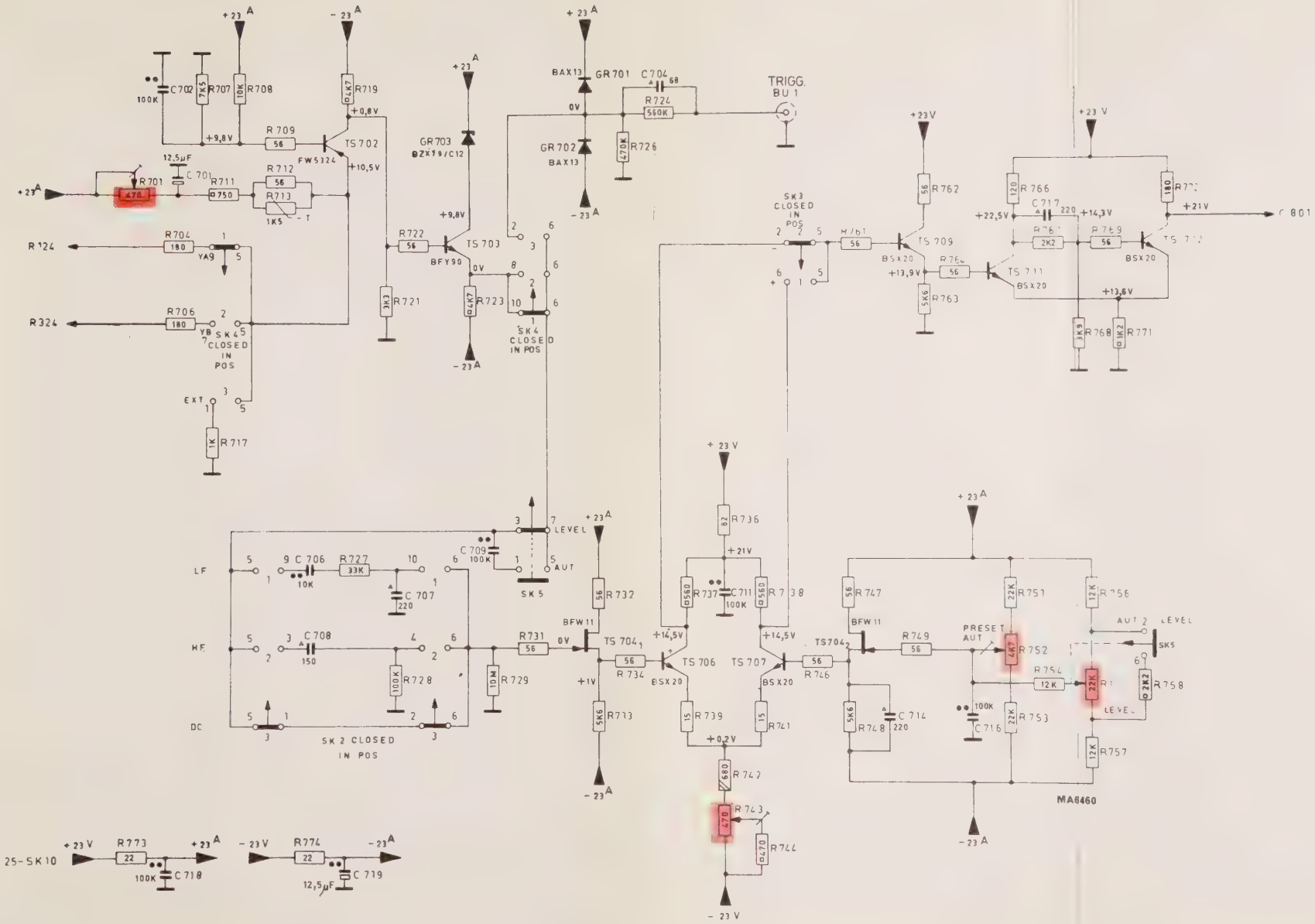


Fig. 62. Circuit diagram of the trigger amplifier

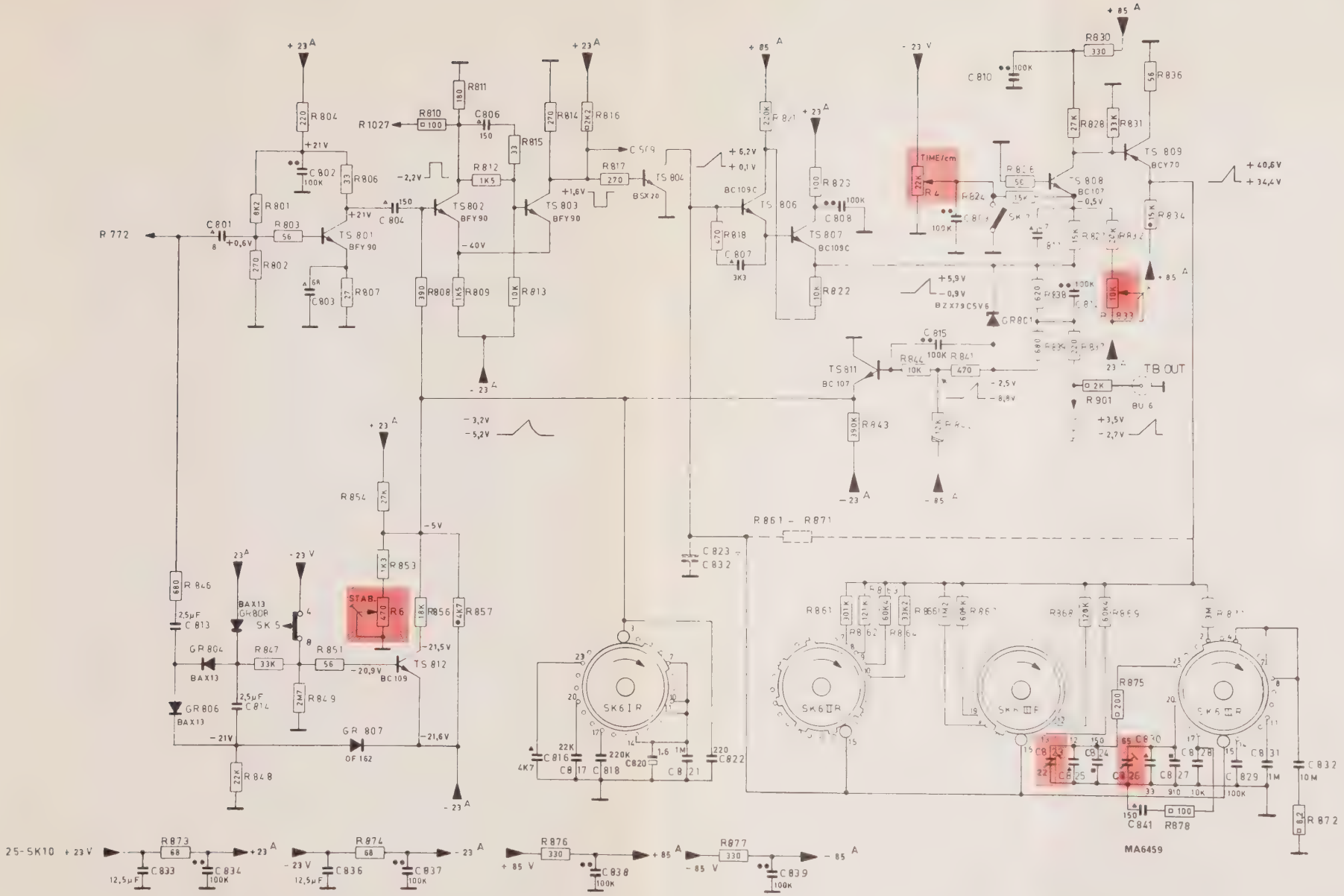


Fig. 63. Circuit diagram of the time-base generator

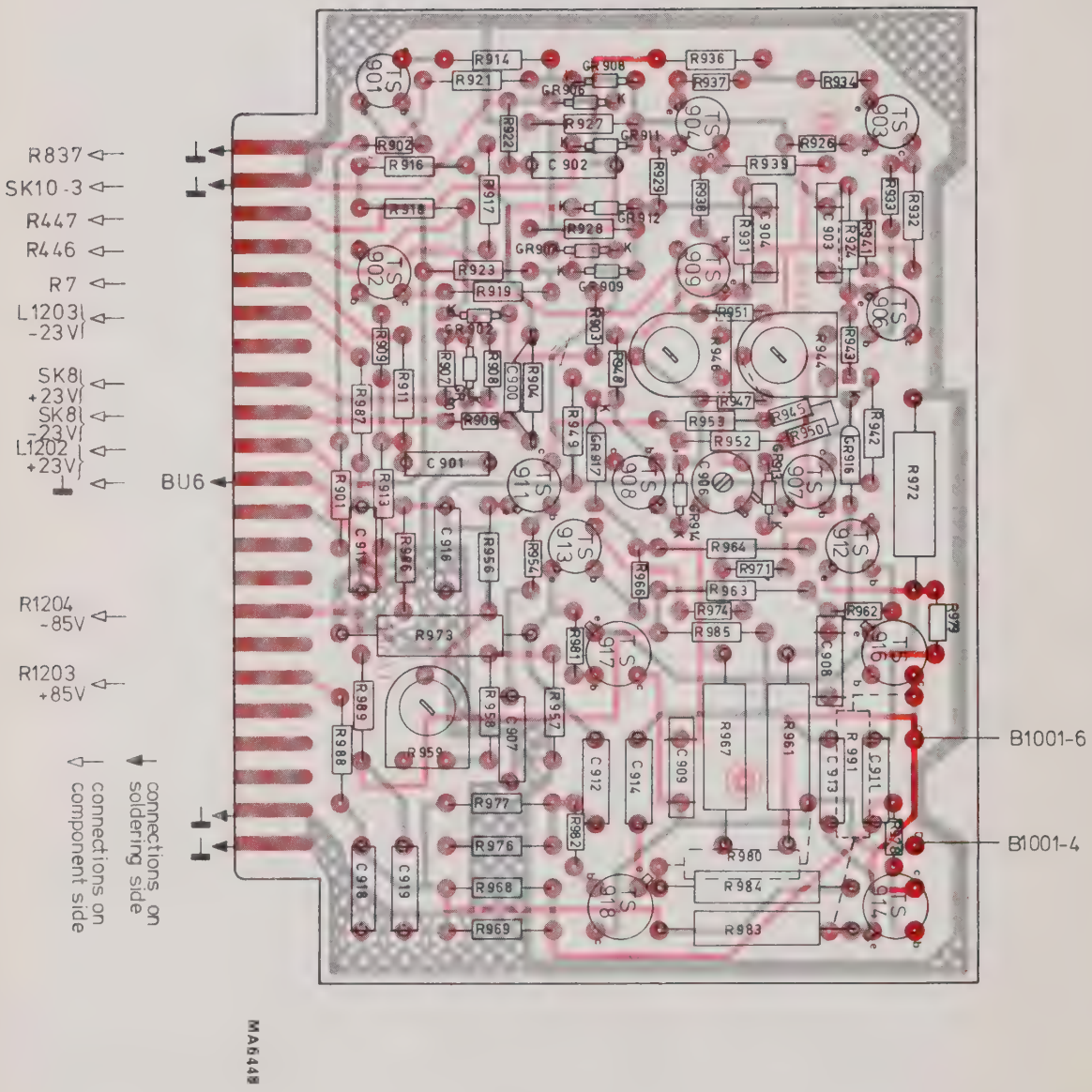


Fig. 64. Unit 7. Horizontal amplifier

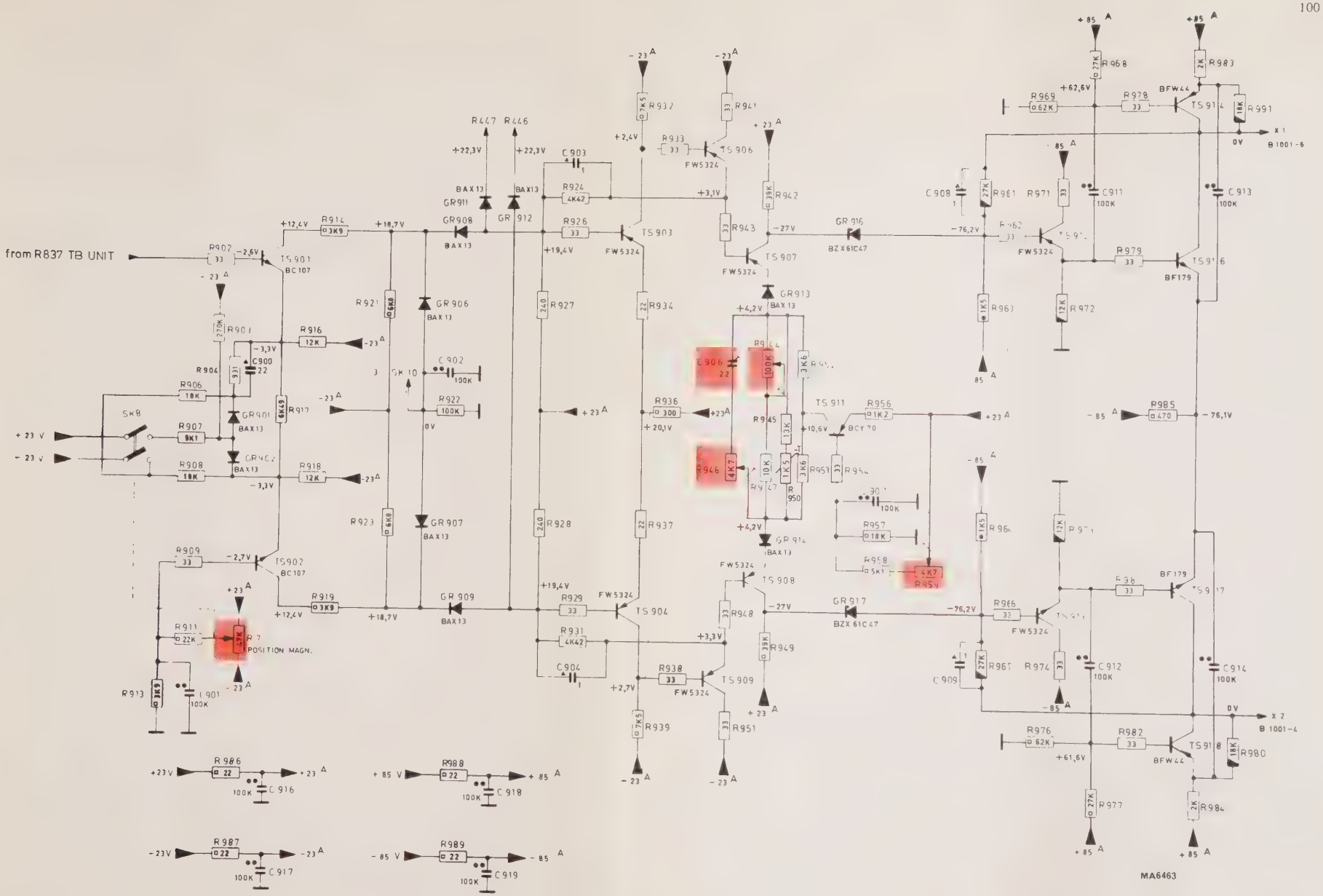


Fig. 65. Circuit diagram of the horizontal amplifier

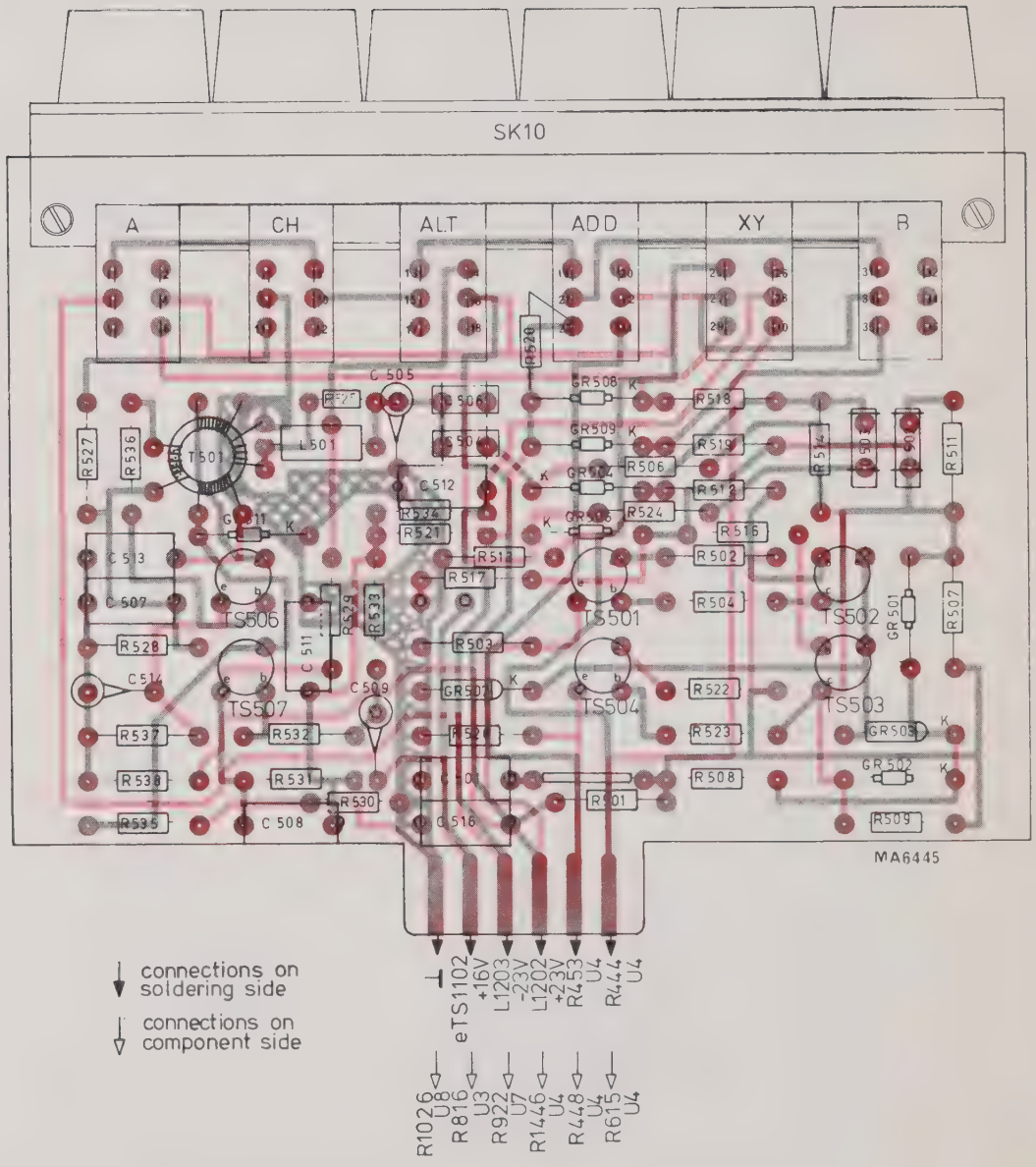


Fig. 66. Unit 5. Switch unit

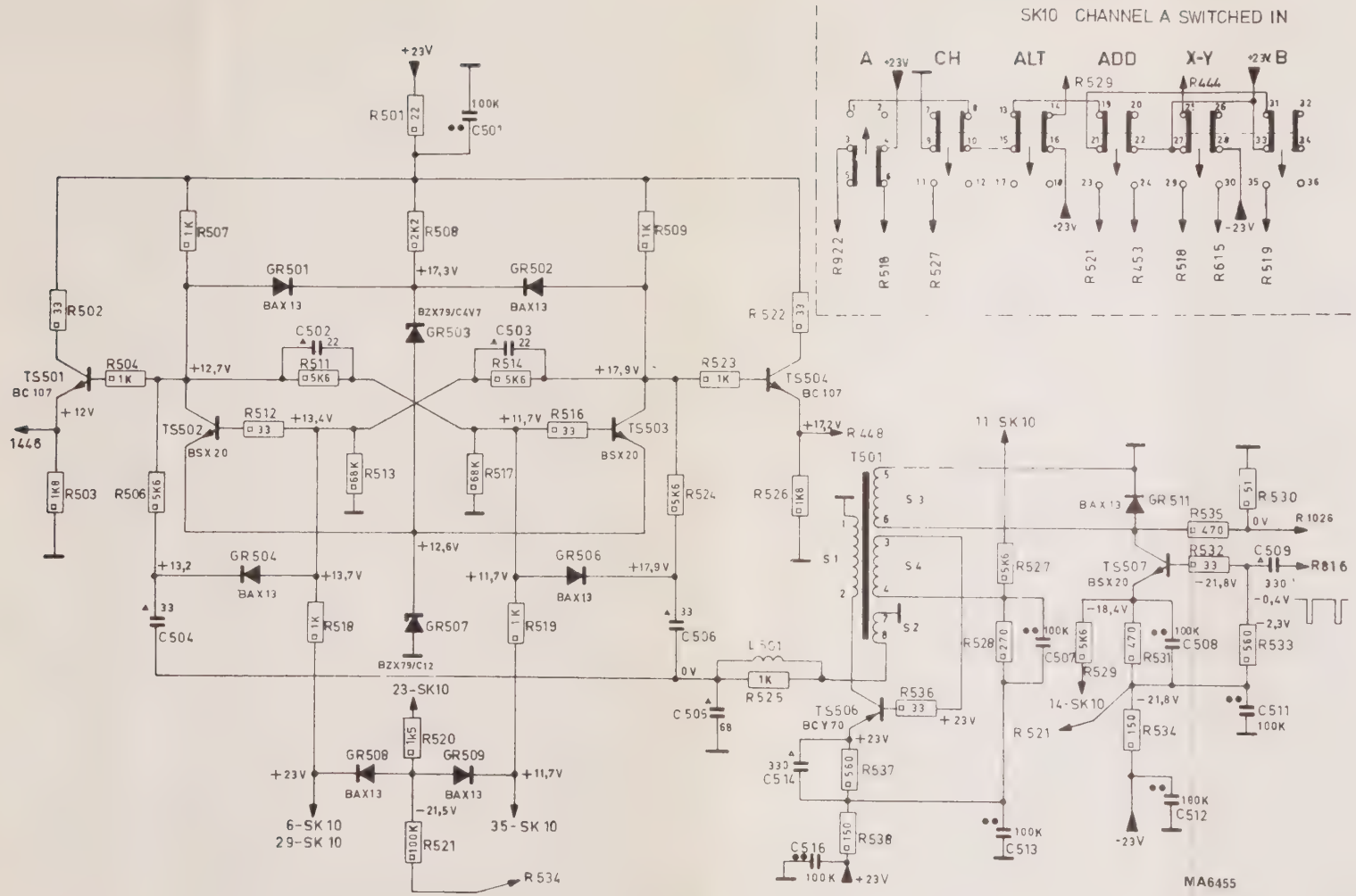


Fig. 67. Circuit diagram of the switch unit

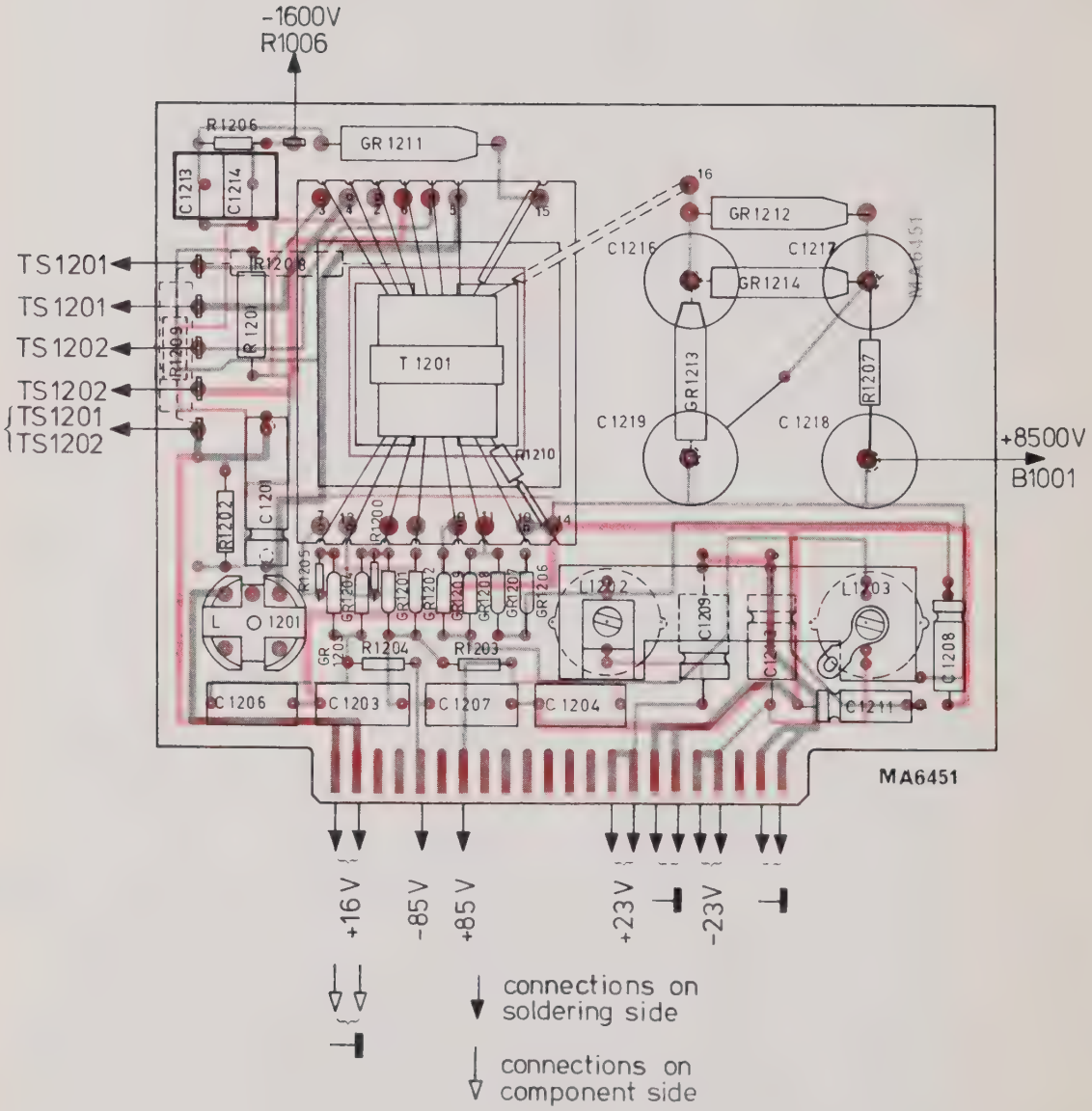
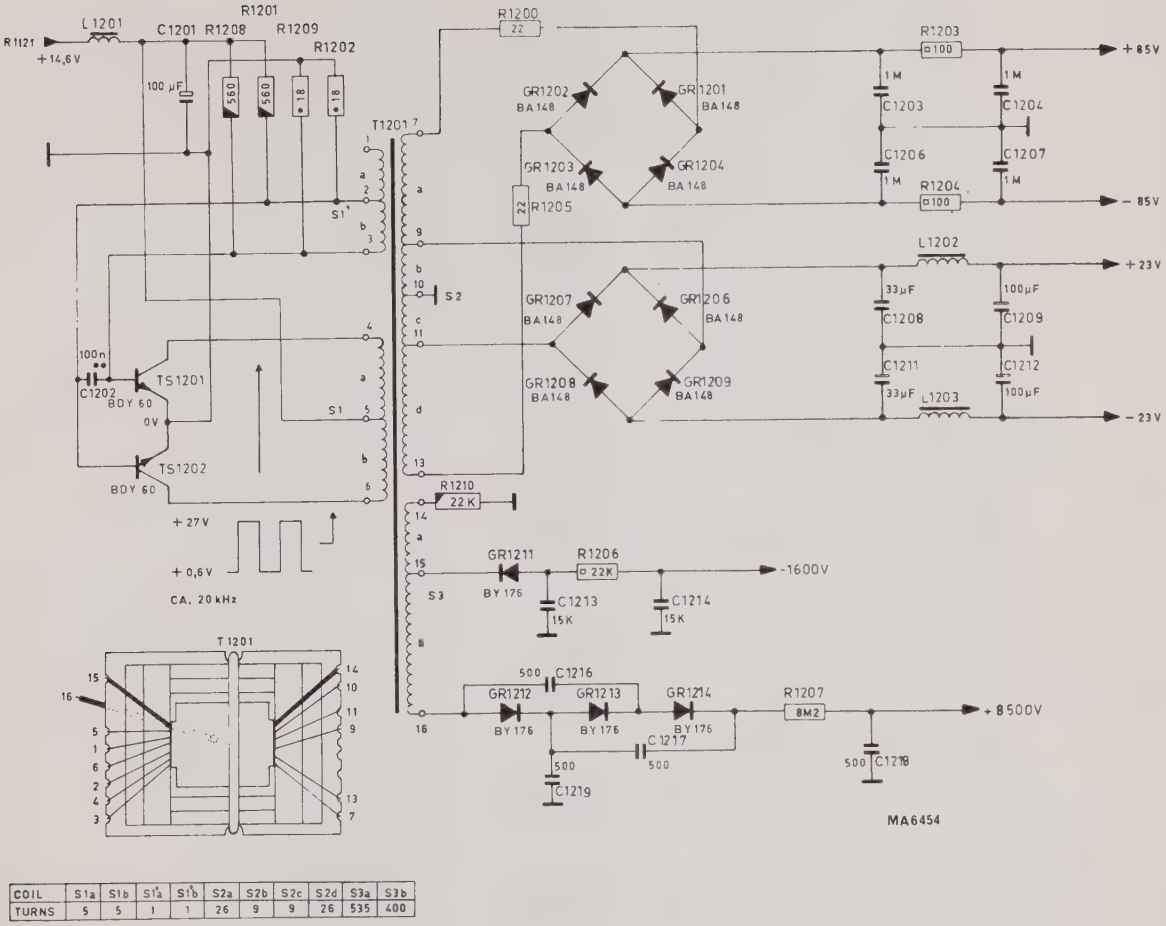


Fig. 68. Unit 6. Convertor unit



COIL	S1a	S1b	S1'a	S1'b	S2a	S2b	S2c	S2d	S3a	S3b
TURNS	5	5	1	1	26	9	9	26	535	400

Fig. 69. Circuit diagram of the convertor unit

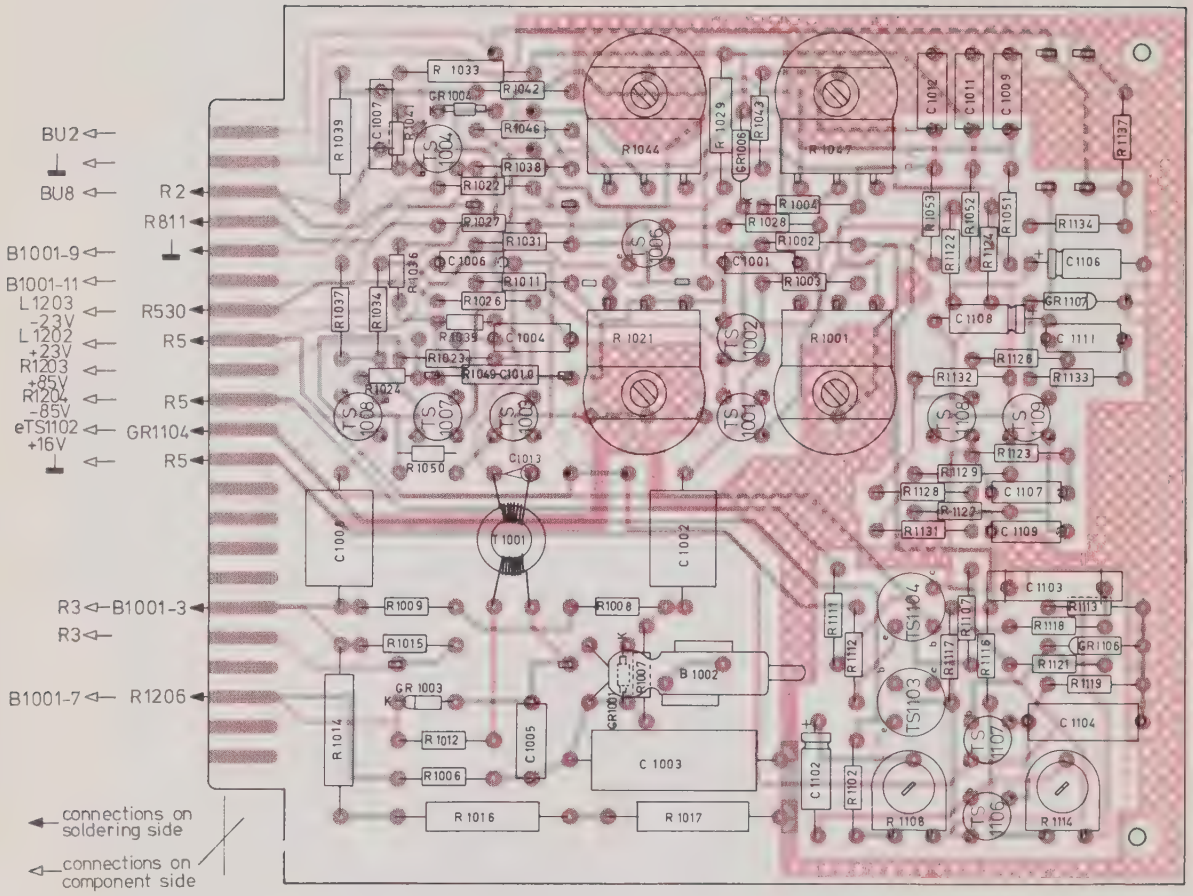
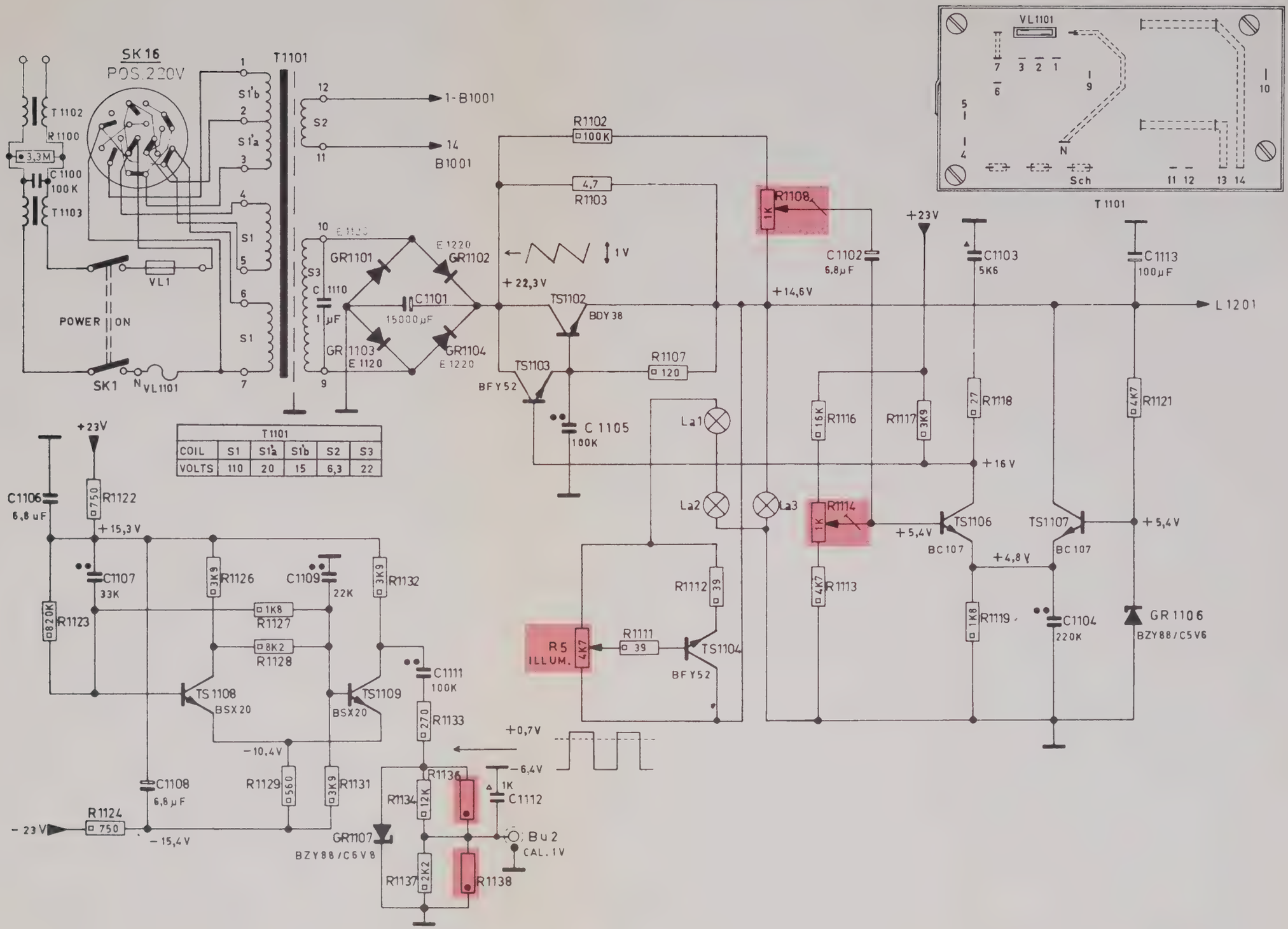


Fig. 70. Unit 8. Combination unit



T1101					
COIL	S1	S1'a	S1'b	S2	S3
VOLTS	110	20	15	6,3	22

Fig. 71. Circuit diagram of the stabilized power supply and the calibration unit

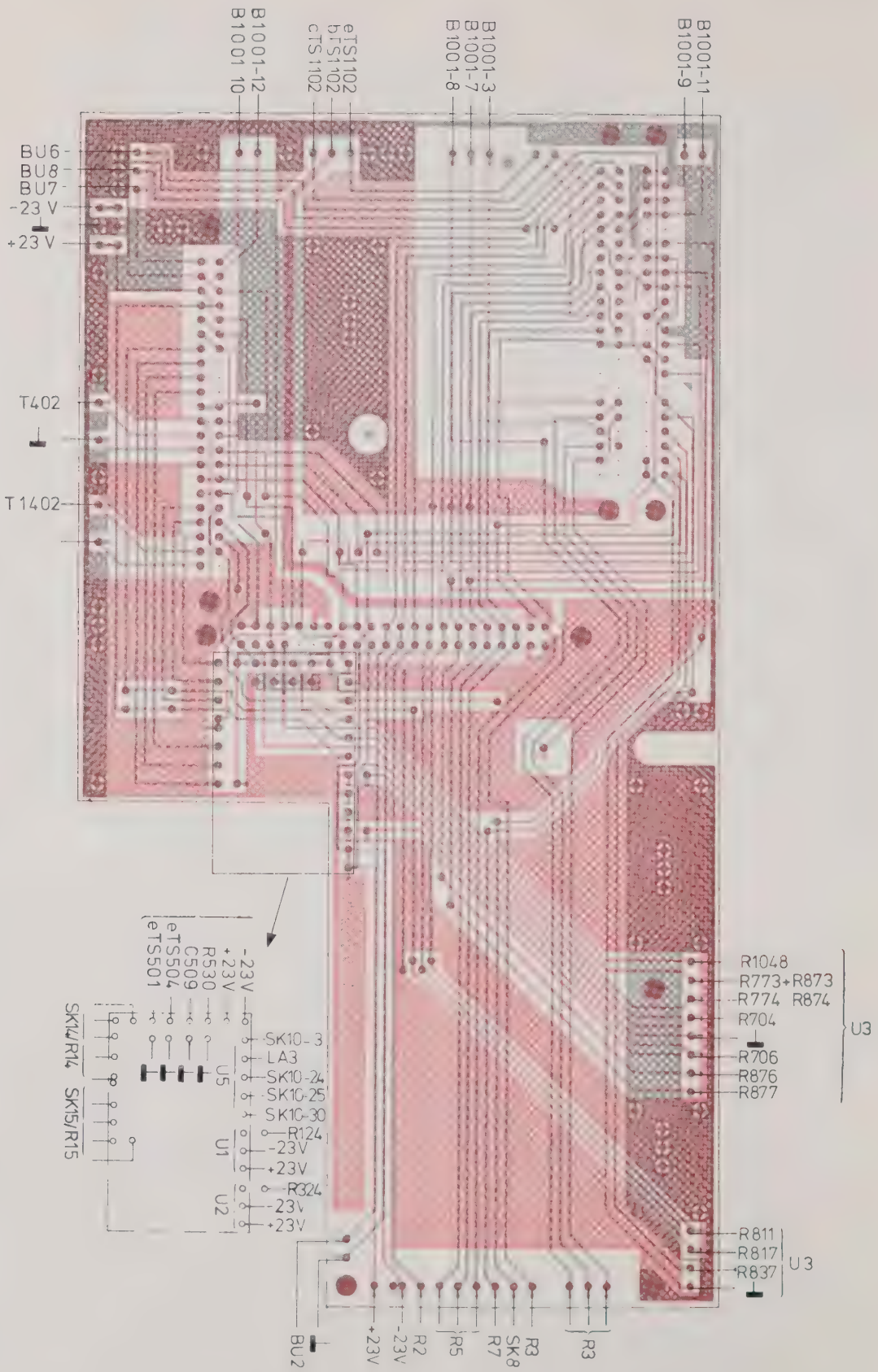


Fig. 72. Unit 9. Wiring unit

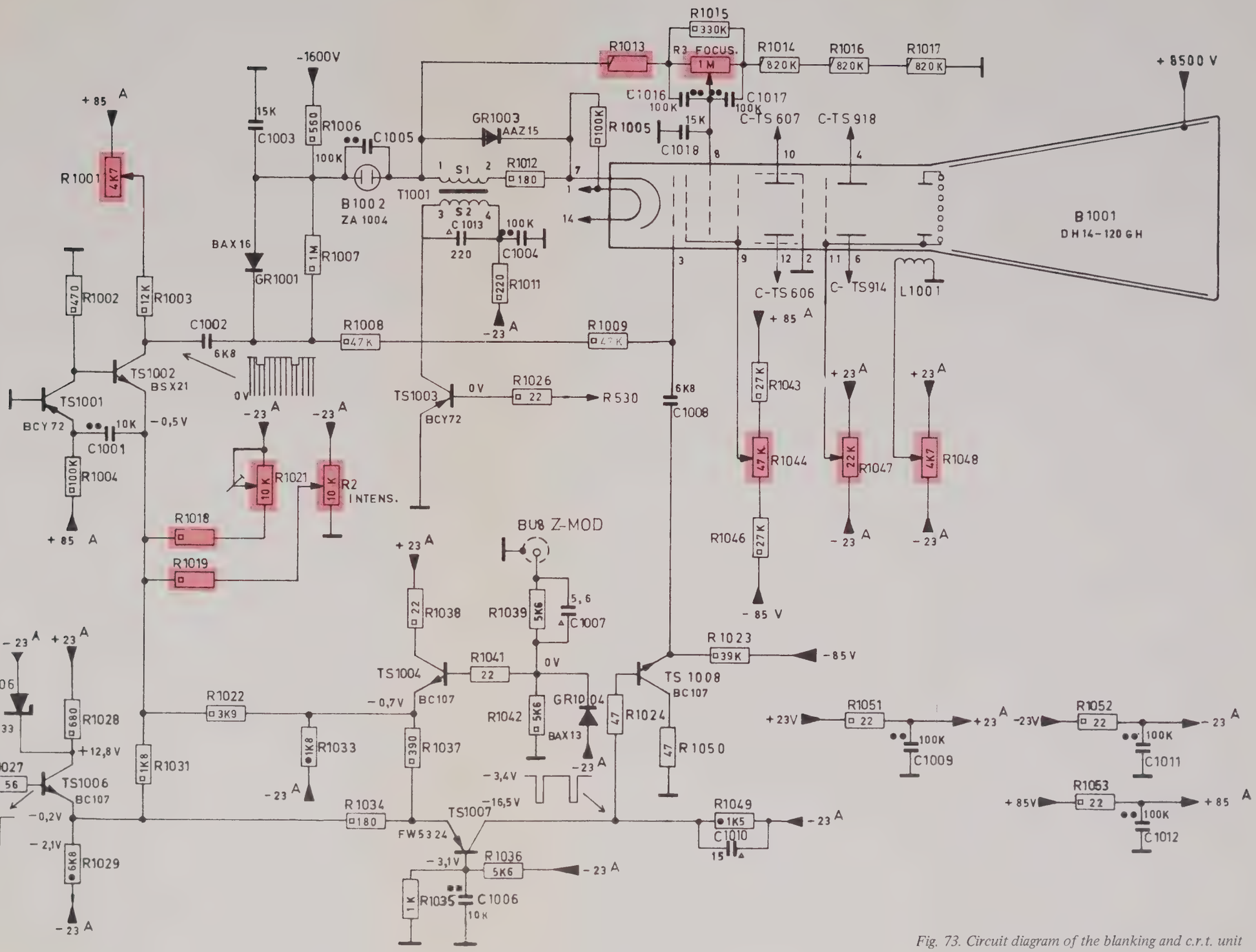


Fig. 73. Circuit diagram of the blanking and c.r.t. unit

A. CAPACITORS

Item	Code number	Value	Volt	Description
C26	5322 121 40145	100 nF	630 V	Polyester
C28	5322 125 60067	8 pF	300 V	Trimmer
C29	5322 125 60067	8 pF	300 V	Trimmer
C32	5322 125 60067	8 pF	300 V	Trimmer
C33	5322 125 60067	8 pF	300 V	Trimmer
C34	5322 125 60067	8 pF	300 V	Trimmer
C35	4822 122 30016	33 pF	63 V	Miniature ceramic
C36	5322 125 60067	8 pF	300 V	Trimmer
C37	4822 122 70082	6.8 pF	350 V	Feed-through
C38	5322 125 60067	8 pF	300 V	Trimmer
C39	5322 125 60067	8 pF	300 V	Trimmer
C41	5322 123 10197	100 pF	300 V	Disc
C42	5322 125 60067	8 pF	300 V	Trimmer
C43	5322 125 60067	8 pF	300 V	Trimmer
C44	5322 123 10236	1 nF	300 V	Disc
C46	4822 122 30027	1 nF	100 V	Miniature ceramic
C48	4822 122 30043	10 nF	40 V	Miniature ceramic
C51	4822 122 30043	10 nF	40 V	Miniature ceramic
C52	5322 122 30022	22 pF	63 V	Miniature ceramic
C53	4822 122 30043	10 nF	40 V	Miniature ceramic
C54	4822 122 30043	10 nF	40 V	Miniature ceramic
C55	4822 122 30043	10 nF	40 V	Miniature ceramic
C56	4822 122 30043	10 nF	40 V	Miniature ceramic
C57	4822 122 30043	10 nF	40 V	Miniature ceramic
C59	4822 124 20355	12.5 μF	25 V	Electrolytic
C60	5322 122 30022	22 pF	63 V	Miniature ceramic
C62	4822 124 20355	12.5 μF	25 V	Electrolytic
C64	4822 122 30008	47 pF	63 V	Miniature ceramic
C226	5322 121 40145	100 nF	630 V	Polyester
C228	5322 125 60067	8 pF	300 V	Trimmer
C229	5322 125 60067	8 pF	300 V	Trimmer
C232	5322 125 60067	8 pF	300 V	Trimmer
C233	5322 125 60067	8 pF	300 V	Trimmer
C234	5322 125 60067	8 pF	300 V	Trimmer
C235	4822 122 30016	33 pF	63 V	Miniature ceramic
C236	5322 125 60067	8 pF	300 V	Trimmer
C237	4822 122 70082	6.8 pF	350 V	Feed-through
C238	5322 125 60067	8 pF	300 V	Trimmer
C239	5322 125 60067	8 pF	300 V	Trimmer
C241	5322 123 10197	100 pF	300 V	Disc
C242	5322 125 60067	8 pF	300 V	Trimmer
C243	5322 125 60067	8 pF	300 V	Trimmer
C244	5322 123 10236	1 nF	300 V	Disc
C246	4822 122 30027	1 nF	100 V	Miniature ceramic
C248	4822 122 30043	10 nF	40 V	Miniature ceramic
C251	4822 122 30043	10 nF	40 V	Miniature ceramic
C252	5322 122 30022	22 pF	63 V	Miniature ceramic
C253	4822 122 30043	10 nF	40 V	Miniature ceramic
C254	4822 122 30043	10 nF	40 V	Miniature ceramic
C255	4822 122 30043	10 nF	40 V	Miniature ceramic

Item	Code number	Value	Volt	Description
C256	4822 122 30043	10 nF	40 V	Miniature ceramic
C257	4822 122 30043	10 nF	40 V	Miniature ceramic
C259	4822 124 20355	12.5 µF	25 V	Electrolytic
C260	5322 122 30022	22 pF	63 V	Miniature ceramic
C262	4822 124 20355	12.5 µF	25 V	Electrolytic
C264	4822 122 30008	47 pF	63 V	Miniature ceramic
C402	4822 125 50017	65 pF	50 V	Trimmer
C403	4822 125 50017	65 pF	50 V	Trimmer
C404	5322 122 34005	330 pF	63 V	Miniature ceramic
C406	4822 122 30099	3.3 nF	100 V	Miniature ceramic
C407	4822 125 50017	65 pF	50 V	Trimmer
C409	4822 122 30097	15 pF	63 V	Miniature ceramic
C413	4822 122 30104	1 pF	63 V	Miniature ceramic
C414	4822 122 30104	1 pF	63 V	Miniature ceramic
C602	4822 125 50045	22 pF	100 V	Miniature ceramic
C603	4822 122 30008	47 pF	63 V	Miniature ceramic
C604	4822 122 30008	47 pF	63 V	Miniature ceramic
C605	4822 122 30099	3.3 nF	100 V	Miniature ceramic
C701	4822 124 20355	12.5 µF	25 V	Electrolytic
C719	4822 124 20355	12.5 µF	25 V	Electrolytic
C813	4822 124 20095	2.5 µF	64 V	Electrolytic
C814	4822 124 20095	2.5 µF	64 V	Electrolytic
C817	4822 121 40171	22 nF	250 V	Polyester
C818	4822 121 40061	220 nF	250 V	Polyester
C820	4822 124 20342	1.6 µF	25 V	Electrolytic
C821	5322 121 40176	1 µF	100 V	Polyester
C822	4822 120 10089	220 pF	700 V	Ceramic
C823	4822 125 50045	22 pF	50 V	Trimmer
C826	4822 125 50017	65 pF	50 V	Trimmer
C828		10 nF	200 V	
C829	5322 111 30192	100 nF	200 V	Box-capacitor
C831		1 µF	200 V	
C832	5322 121 10105	10 µF	200 V	Box-capacitor
C833	4822 124 20355	12.5 µF	25 V	Electrolytic
C836	4822 124 20355	12.5 µF	25 V	Electrolytic
C906	4822 125 50045	22 pF	50 V	Trimmer
C1002	4822 121 40326	6.8 nF	1600 V	Polyester
C1003	5322 121 40123	15 nF	1600 V	Polyester
C1008	5322 121 40326	6.8 nF	1600 V	Polyester
C1018	5322 121 40123	15 nF	1600 V	Polyester
C1100	5322 121 20173	100 nF	250 V	Paper/Polyester
C1101	5322 124 70222	2x7500 µF	25 V	Electrolytic
C1102	4822 124 20351	6.8 µF	40 V	Electrolytic
C1106	4822 124 20351	6.8 µF	40 V	Electrolytic
C1108	4822 124 20351	6.8 µF	40 V	Electrolytic
C1110	4822 121 40013	1 µF	250 V	Polyester
C1201	4822 121 20337	100 µF	40 V	Electrolytic
C1203	5322 121 40197	1 µF	100 V	Polyester
C1204	5322 121 40197	1 µF	100 V	Polyester
C1206	5322 121 40197	1 µF	100 V	Polyester
C1207	5322 121 40197	1 µF	100 V	Polyester

Item	Code number	Value	Volt	Description
C1208	4822 124 20366	33 µF	40 V	Electrolytic
C1209	5322 124 20337	100 µF	40 V	Electrolytic
C1211	4822 124 20366	33 µF	40 V	Electrolytic
C1212	5322 124 20337	100 µF	40 V	Electrolytic
C1213	5322 121 40123	15 nF	1600 V	Polyester
C1214	5322 121 40123	15 nF	1600 V	Polyester
C1216	5322 121 30077	500 pF	10 kV	High tension
C1217	5322 121 30077	500 pF	10 kV	High tension
C1218	5322 121 30077	500 pF	10 kV	High tension
C1219	5322 121 30077	500 pF	10 kV	High tension
C1402	4822 125 50017	65 pF	50 V	Trimmer
C1403	4822 125 50017	65 pF	50 V	Trimmer
C1404	5322 122 34005	330 pF	63 V	Miniature ceramic
C1406	5322 122 30099	3.3 nF	100 V	Miniature ceramic
C1407	4822 125 50017	65 pF	50 V	Trimmer

B. RESISTORS

Item	Code number	Value		Watt	%	Description
R1	5322 101 60048	22	kΩ	0.125	20	Potentiometer with switch (SK5)
R2	4822 101 30229	10	kΩ	0.125	20	Potentiometer
R3	5322 101 20376	1	MΩ	0.125	20	Potentiometer
R4	5322 101 40072	22	kΩ	0.125	20	Potentiometer with switch (SK7)
R5	5322 101 20341	4.7	kΩ	0.125	20	Potentiometer
R6	5322 101 20267	470	Ω	0.1	20	Potentiometer
R7	4822 101 60055	47	kΩ	0.125	20	Potentiometer with switch (SK8)
R8	5322 101 20422	500	Ω	0.125	20	Potentiometer
R9	5322 101 20288	1	kΩ	0.1	20	Potentiometer
R10	4822 101 20424	2.2	kΩ	0.1	20	Potentiometer
R11	4822 101 20424	2.2	kΩ	0.1	20	Potentiometer
R12	5322 101 20288	1	kΩ	0.1	20	Potentiometer
R13	4822 101 20422	500	Ω	0.125	20	Potentiometer
R14	5322 101 60048	22	kΩ	0.125	20	Potentiometer with switch (SK14)
R15	5322 101 60048	22	kΩ	0.125	20	Potentiometer with switch (SK15)
R26	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R27	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R28	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R29	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R31	4822 111 20332	920	kΩ	0.25	1	Carbon resistor
R32	5322 116 50821	88.7	kΩ	0.25	1	Metal film resistor
R33	4822 111 20333	992	kΩ	0.25	1	Carbon resistor
R34	5322 116 50914	8.06	kΩ	0.25	1	Metal film resistor
R36	5322 111 20317	1	MΩ	0.125	1	Carbon resistor
R37	5322 116 50808	796	Ω	0.1	0.5	Metal film resistor
R46	5322 111 30304	150	kΩ	0.1	5	Carbon resistor
R47	5322 111 20147	800	kΩ	0.25	1	Carbon resistor
R48	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R49	4822 111 30394	2.2	MΩ	0.125	10	Carbon resistor
R51	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R52	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R53	4822 111 30263	3.3	kΩ	0.1	5	Carbon resistor
R54	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R56	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R57	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R58	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R59	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R61	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R62	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R63	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R64	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R66	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R67	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R68	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R69	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R70	5322 111 30275	15	kΩ	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R71	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R72	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R73	5322 111 30378	200	Ω	0.1	5	Carbon resistor
R74	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R75	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R76	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R77	5322 116 51065	133	Ω	0.1	0.25	Metal film resistor
R78	5322 116 51066	237	Ω	0.1	0.25	Metal film resistor
R79	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R81	5322 111 30378	200	Ω	0.1	5	Carbon resistor
R82	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R83	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R84	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R86	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R87	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R88	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R89	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R91	5322 116 50679	237	Ω	0.25	1	Metal film resistor
R92	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R93	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R94	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R96	5322 111 30355	20	Ω	0.1	5	Carbon resistor
R97	5322 116 50983	22.1	Ω	0.25	1	Metal film resistor
R98	5322 116 50788	332	Ω	0.1	0.25	Metal film resistor
R99	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R100	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R101	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R102	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R103	4822 111 30397	240	Ω	0.1	5	Carbon resistor
R106	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R107	4822 111 30303	8.2	kΩ	0.1	5	Carbon resistor
R109	5322 100 10075	100	Ω	0.1	20	Potentiometer
R110	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R111	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R112	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R117	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R118	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R119	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R120	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R121	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R122	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R123	4822 110 60118	2.7	kΩ	0.125	5	Carbon resistor
R124	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R131	4822 111 30271	820	Ω	0.1	5	Carbon resistor
R132	4822 100 10038	470	Ω	0.1	20	Potentiometer
R133	5322 116 50752	1.5	kΩ	0.1	0.25	Metal film resistor
R134	5322 116 50847	499	Ω	0.1	0.25	Metal film resistor
R136	5322 116 51067	249	Ω	0.1	0.25	Metal film resistor
R137	5322 116 50751	150	Ω	0.1	0.25	Metal film resistor
R138	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R139	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R141	5322 111 20147	800	kΩ	0.25	1	Carbon resistor

Item	Code number	Value		Watt	%	Description
R142	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R143	5322 101 20241	1	kΩ	0.1	20	Potentiometer
R144	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R146	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R148	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R149	5322 116 50482	33.2	kΩ	0.25	1	Metal film resistor
R151	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R152	4822 111 30395	4.7	MΩ	0.125	10	Carbon resistor
R162	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R164	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R226	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R227	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R228	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R229	5322 116 50858	200	kΩ	0.25	1	Metal film resistor
R231	4822 111 20332	920	kΩ	0.25	1	Carbon resistor
R232	5322 116 50821	88.7	kΩ	0.25	1	Metal film resistor
R233	4822 111 20333	992	kΩ	0.25	1	Carbon resistor
R234	5322 116 50914	8.06	kΩ	0.25	1	Metal film resistor
R236	5322 111 20317	1	MΩ	0.125	1	Carbon resistor
R237	5322 116 50808	796	Ω	0.1	0.5	Metal film resistor
R246	5322 111 30304	150	kΩ	0.1	5	Carbon resistor
R247	5322 111 20147	800	kΩ	0.25	1	Carbon resistor
R248	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R249	4822 111 30394	2.2	MΩ	0.125	10	Carbon resistor
R251	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R252	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R253	4822 111 30263	3.3	kΩ	0.1	5	Carbon resistor
R254	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R256	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R257	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R258	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R259	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R261	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R262	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R263	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R264	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R266	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R267	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R268	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R269	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R270	5322 111 30275	15	kΩ	0.1	5	Carbon resistor
R271	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R272	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R273	5322 111 30378	200	Ω	0.1	5	Carbon resistor
R274	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R275	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R276	5322 116 50818	44.2	Ω	0.25	1	Metal film resistor
R277	5322 116 51065	133	Ω	0.1	0.25	Metal film resistor
R278	5322 116 51066	237	Ω	0.1	0.25	Metal film resistor
R279	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R281	5322 111 30378	200	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R282	5322 116 50435	226	Ω	0.25	1	Metal film resistor
R283	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R284	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R286	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R287	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R288	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R289	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R291	5322 116 50679	237	Ω	0.25	1	Metal film resistor
R292	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R293	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R294	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R296	5322 111 30355	20	Ω	0.1	5	Carbon resistor
R297	5322 116 50983	22.1	Ω	0.25	1	Metal film resistor
R298	5322 116 50788	332	Ω	0.1	0.25	Metal film resistor
R299	5322 116 50584	619	Ω	0.25	1	Metal film resistor
R300	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R301	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R301	5322 111 30354	12	Ω	0.1	5	Carbon resistor
R302	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R303	4822 111 30397	240	Ω	0.1	5	Carbon resistor
R306	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R307	4822 111 30303	8.2	kΩ	0.1	5	Carbon resistor
R309	5322 100 10075	100	Ω	0.1	20	Potentiometer
R310	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R311	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R312	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R317	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R318	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R319	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R320	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R321	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R322	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R323	4822 110 60118	2.7	kΩ	0.125	5	Carbon resistor
R324	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R331	4822 111 30271	820	Ω	0.1	5	Carbon resistor
R332	4822 100 10038	470	Ω	0.1	20	Potentiometer
R333	5322 116 50752	1.5	kΩ	0.1	0.25	Metal film resistor
R334	5322 116 50847	499	Ω	0.1	0.25	Metal film resistor
R336	5322 116 51067	249	Ω	0.1	0.25	Metal film resistor
R337	5322 116 50751	150	Ω	0.1	0.25	Metal film resistor
R338	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R339	5322 116 51069	49.9	Ω	0.1	0.25	Metal film resistor
R341	5322 111 20147	800	kΩ	0.25	1	Carbon resistor
R342	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R343	5322 101 20241	1	kΩ	0.1	20	Potentiometer
R344	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R346	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R348	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R349	5322 116 50482	33.2	kΩ	0.25	1	Metal film resistor
R351	5322 111 30377	10	MΩ	0.125	10	Carbon resistor
R352	4822 111 30395	4.7	MΩ	0.125	10	Carbon resistor
R362	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R364	4822 111 30348	27	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R401	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R402	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R403	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R404	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R406	5322 111 30289	56	kΩ	0.1	5	Carbon resistor
R407	5322 100 10079	47	kΩ	0.1	20	Potentiometer
R408	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R411	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R416	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R417	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R418	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R424	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R426	4822 110 60109	1.2	kΩ	0.125	5	Carbon resistor
R428	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R429	4822 100 10038	470	Ω	0.1	20	Potentiometer
R430	4822 100 10035	10	kΩ	0.1	20	Potentiometer
R431	4822 100 10029	2.2	kΩ	0.1	20	Potentiometer
R432	4822 111 30279	33	kΩ	0.1	5	Carbon resistor
R434	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R435	4822 111 30276	18	kΩ	0.1	5	Carbon resistor
R437	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R438	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R439	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R441	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R442	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R443	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R444	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R446	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R447	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R448	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R449	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R450	5322 116 50442	48.7	kΩ	0.25	1	Metal film resistor
R453	5322 116 50595	2.37	kΩ	0.25	1	Metal film resistor
R454	5322 116 50414	2.87	kΩ	0.25	1	Metal film resistor
R455	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R456	5322 116 50664	2.05	kΩ	0.25	1	Metal film resistor
R457	5322 116 50554	750	Ω	0.25	1	Metal film resistor
R458	5322 116 50571	715	Ω	0.25	1	Metal film resistor
R459	5322 116 50664	2.05	kΩ	0.25	1	Metal film resistor
R461	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R462	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R463	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R465	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R466	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R467	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R468	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R481	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R482	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R483	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R484	4822 111 30399	33	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R486	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R487	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R525	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R601	4822 111 30398	300	Ω	0.125	5	Carbon resistor
R602	5322 100 10036	4.7	kΩ	0.1	20	Potentiometer
R603	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R604	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R605	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R606	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R607	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R608	5322 111 44015	430	Ω	0.1	5	Carbon resistor
R609	5322 100 10075	100	Ω	0.1	20	Potentiometer
R610	5322 111 30291	68	kΩ	0.1	5	Carbon resistor
R611	4822 111 30267	1.5	kΩ	0.1	5	Carbon resistor
R612	5322 111 44015	430	Ω	0.1	5	Carbon resistor
R613	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R614	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R615	5322 116 50554	750	Ω	0.25	5	Carbon resistor
R616	5322 100 10036	4.7	kΩ	0.1	20	Potentiometer
R617	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R620	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R622	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R623	4822 110 50116	2.2	kΩ	0.25	5	Carbon resistor
R624	5322 111 30124	4.3	kΩ	0.1	5	Carbon resitor
R625	5322 116 30079	1.5	kΩ	0.5	20	N.t.c. resistor
R628	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R632	4822 110 50116	2.2	kΩ	0.25	5	Carbon resistor
R634	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R701	4822 101 20426	470	Ω	0.1	20	Potentiometer
R704	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R706	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R707	4822 111 30402	7.5	kΩ	0.1	5	Carbon resistor
R708	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R709	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R712	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R713	5322 116 30079	1.5	kΩ	0.5	20	NTC-resistor
R717	4822 111 30269	1	kΩ	0.1	5	Carbon resistor
R721	4822 111 30263	3.3	kΩ	0.1	5	Carbon resistor
R722	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R724	5322 111 30261	560	kΩ	0.1	10	Carbon resistor
R726	5322 111 30259	470	kΩ	0.1	10	Carbon resistor
R727	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R728	5322 111 30296	100	kΩ	0.1	10	Carbon resistor
R729	5322 111 30342	10	MΩ	0.125	10	Carbon resistor
R731	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R732	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R733	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R734	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R736	4822 111 30352	82	Ω	0.1	5	Carbon resistor
R739	4822 111 30173	15	Ω	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R741	4822 111 30173	15	Ω	0.1	5	Carbon resistor
R743	4822 101 20426	470	Ω	0.1	20	Potentiometer
R746	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R747	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R748	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R749	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R751	5322 111 30277	22	kΩ	0.1	5	Carbon resistor
R752	5322 101 20243	4.7	kΩ	0.1	20	Potentiometer
R753	5322 111 30277	22	kΩ	0.1	5	Carbon resistor
R754	4822 111 30274	12	kΩ	0.1	5	Carbon resistor
R756	4822 111 30274	12	kΩ	0.1	5	Carbon resistor
R757	4822 111 30274	12	kΩ	0.1	5	Carbon resistor
R761	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R762	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R763	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R764	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R766	5322 111 30298	120	Ω	0.1	5	Carbon resistor
R767	4822 111 30265	2.2	kΩ	0.1	5	Carbon resistor
R768	4822 111 30311	3.9	kΩ	0.1	5	Carbon resistor
R769	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R772	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R773	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R774	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R801	4822 111 30303	8.2	kΩ	0.1	5	Carbon resistor
R802	4822 111 30323	270	Ω	0.1	5	Carbon resistor
R803	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R804	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R806	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R807	4822 111 30348	27	Ω	0.1	5	Carbon resistor
R808	4822 111 30329	390	Ω	0.1	5	Carbon resistor
R811	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R812	4822 111 30267	1.5	kΩ	0.1	5	Carbon resistor
R813	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R814	4822 111 30323	270	Ω	0.1	5	Carbon resistor
R817	4822 111 30323	270	Ω	0.1	5	Carbon resistor
R818	4822 111 30331	470	Ω	0.1	5	Carbon resistor
R821	5322 111 30302	220	kΩ	0.1	5	Carbon resistor
R822	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R823	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R824	5322 111 30275	15	kΩ	0.1	5	Carbon resistor
R826	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R827	5322 111 30275	15	kΩ	0.1	5	Carbon resistor
R828	5322 111 30278	27	kΩ	0.1	5	Carbon resistor
R830	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R831	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R832*	5322 111 30276	18	kΩ	0.1	5	Carbon resistor
R833	4822 100 10035	10	kΩ	0.1	20	Potentiometer
R836	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R837	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R838	5322 111 34094	620	Ω	0.1	5	Carbon resistor

*) In PM 3210/03 models 20 kΩ, 0.1 W, order no. 4822 111 30142

Item	Code number	Value		Watt	%	Description
R839	5322 111 30272	680	Ω	0.1	5	Carbon resistor
R841	4822 111 30331	470	Ω	0.1	5	Carbon resistor
R843	5322 111 30258	390	kΩ	0.1	10	Carbon resistor
R844	4822 111 30273	10	kΩ	0.1	5	Carbon resistor
R846	4822 111 30272	680	Ω	0.1	5	Carbon resistor
R847	5322 111 30279	33	kΩ	0.1	5	Carbon resistor
R848	5322 111 30277	22	kΩ	0.1	5	Carbon resistor
R849	4822 110 50198	2.7	MΩ	0.125	10	Carbon resistor
R851	5322 111 30074	56	Ω	0.1	5	Carbon resistor
R853	5322 111 30359	1.3	kΩ	0.1	5	Carbon resistor
R854	5322 111 30278	27	kΩ	0.1	5	Carbon resistor
R856	5322 111 30270	18	kΩ	0.1	5	Carbon resistor
R861	5322 116 51027	301	kΩ	0.25	1	Metal film resistor
R862	5322 116 50594	121	kΩ	0.125	1	Metal film resistor
R863	5322 116 50626	60.4	kΩ	0.125	0.5	Metal film resistor
R864	5322 116 51068	33.2	kΩ	0.125	0.5	Metal film resistor
R866	5322 110 30189	1.2	MΩ	0.25	1	Carbon resistor
R867	5322 116 51033	604	kΩ	0.25	1	Metal film resistor
R868	5322 116 50594	121	kΩ	0.125	1	Metal film resistor
R869	5322 116 50626	60.4	kΩ	0.125	0.5	Metal film resistor
R871	4822 111 40201	3	MΩ	0.25	1	Carbon resistor
R873	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R874	4822 111 30383	68	Ω	0.1	5	Carbon resistor
R876	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R877	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R902	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R903	5322 111 30256	270	kΩ	0.1	5	Carbon resistor
R904	5322 116 51071	931	Ω	0.1	0.5	Metal film resistor
R906	5322 111 30276	18	kΩ	0.1	5	Carbon resistor
R907	5322 111 30133	9.1	kΩ	0.1	5	Carbon resistor
R908	5322 111 30276	18	kΩ	0.1	5	Carbon resistor
R909	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R916	4822 110 60136	12	kΩ	0.125	2	Carbon resistor
R917	5322 116 50176	6.49	kΩ	0.1	0.5	Metal film resistor
R918	4822 110 60136	12	kΩ	0.125	2	Carbon resistor
R922	5322 111 30296	100	kΩ	0.1	5	Carbon resistor
R924	5322 116 50556	4.42	kΩ	0.25	1	Metal film resistor
R926	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R927	4822 110 60091	240	Ω	0.125	2	Carbon resistor
R928	4822 110 60091	240	Ω	0.125	2	Carbon resistor
R929	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R931	5322 116 50556	4.42	kΩ	0.25	1	Metal film resistor
R933	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R934	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R937	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R938	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R941	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R943	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R944	5322 100 10052	100	kΩ	0.1	20	Potentiometer
R945	5322 111 30137	13	kΩ	0.1	5	Carbon resistor
R946	5322 100 10036	4.7	kΩ	0.1	20	Potentiometer
R947	4822 111 30273	10	kΩ	0.1	5	Carbon resistor

Item	Code number	Value		Watt	%	Description
R948	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R950	5322 116 30079	1.5	kΩ	0.5	20	N.t.c. resistor
R951	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R952	4822 110 60122	3.6	kΩ	0.125 W	5	Carbon resistor
R953	4822 110 60122	3.6	kΩ	0.125 W	5	Carbon resistor
R954	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R959	5322 100 10036	4.7	kΩ	0.1	20	Potentiometer
R962	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R966	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R971	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R974	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R978	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R979	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R981	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R982	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R983	4822 110 30115	2	kΩ	0.5	5	Carbon resistor
R984	4822 110 30115	2	kΩ	0.5	5	Carbon resistor
R1001	5322 101 20243	4.7	kΩ	0.1	20	Potentiometer
R1021	4822 101 20425	10	kΩ	0.1	20	Potentiometer
R1024	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R1035	5322 111 44016	910	Ω	0.1	5	Carbon resistor
R1036	4822 111 30313	5.6	kΩ	0.1	5	Carbon resistor
R1041	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R1044	5322 101 20279	47	kΩ	0.1	20	Potentiometer
R1047	4822 101 20239	22	kΩ	0.1	20	Potentiometer
R1048	4822 103 20091	4.7	kΩ	3	5	Potentiometer
R1050	4822 111 30401	47	Ω	0.1	5	Carbon resistor
R1103	4822 115 40197	4.7	Ω	16	5	Wire wound resistor
R1108	5322 100 10037	1	kΩ	0.1	20	Potentiometer
R1114	5322 100 10037	1	kΩ	0.1	20	Potentiometer
R1200	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R1205	4822 111 30396	22	Ω	0.1	5	Carbon resistor
R1207	5322 111 50345	8.2	MΩ	1	5	Carbon resistor
R1401	4822 111 30327	220	Ω	0.1	5	Carbon resistor
R1402	4822 111 30328	330	Ω	0.1	5	Carbon resistor
R1403	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1404	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1406	5322 111 30289	56	kΩ	0.1	5	Carbon resistor
R1407	5322 100 10079	47	kΩ	0.1	20	Potentiometer
R1408	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1411	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R1416	4822 111 30324	100	Ω	0.1	5	Carbon resistor
R1417	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1418	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1424	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1428	4822 111 30326	180	Ω	0.1	5	Carbon resistor
R1429	4822 100 10038	470	Ω	0.1	20	Potentiometer
R1430	4822 100 10035	10	kΩ	0.1	20	Potentiometer
R1431	4822 100 10029	2.2	kΩ	0.1	20	Potentiometer
R1432	4822 111 30279	33	kΩ	0.1	5	Carbon resistor
R1434	4822 111 30399	33	Ω	0.1	5	Carbon resistor
R1435	4822 111 30276	18	kΩ	0.1	5	Carbon resistor

Item	Code number	Value	Watt	%	Description
R1437	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1438	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1439	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1441	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1442	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1443	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1444	4822 111 30399	33 Ω	0.1	5	Carbon resistor
R1446	4822 111 30399	33 Ω	0.1	5	Carbon resistor

C. DIODES

Type	Ordering code	Item
AAZ15	4822 130 30229	GR1003
BA148	4822 130 30256	GR1201...GR1209*)
BAX13	4822 130 40182	GR35, GR235, GR403, GR404, GR406, GR407, GR408, GR409, GR411, GR501, GR502, GR504, GR506, GR508, GR509, GR511, GR601, GR602, GR701, GR702, GR804, GR806, GR808, GR901, GR902, GR906, GR907, GR908, GR909, GR911, GR912, GR913, GR914, GR1406, GR1407, GR1408, GR1409.
BAX16	4822 130 30273	GR1001, GR1002, GR1004
BAX17	5322 130 30605	GR26, GR27, GR28, GR226, GR227, GR228
BY176	4822 130 30588	GR1211, GR1212, GR1213, GR1214
BZX61/C33	4822 130 30786	GR1006
BZX61/C47	5322 130 30565	GR916, GR917
BZY88/C3V3	5322 130 30392	GR29, GR229
BZY88/C3V9	4822 130 30411	GR30, GR34, GR230, GR234
BZX79/C4V7	5322 130 30773	GR503
BZX79/C5V6	5322 130 30759	GR801, GR1106
BZX79/C6V8	5322 130 30778	GR1107
BZX79/C8V2	5322 130 34119	GR32, GR33, GR232, GR233
BZX79/C12	5322 130 34069	GR507, GR703
BZX79/C18	5322 130 34076	GR31, GR231
E1120	5322 130 30541	GR1101, GR1103
E1220	5322 130 30542	GR1102, GR1104
OF162	4822 130 30266	GR807

*) In the PM 3210/03 models, diodes GR1206, 1207, 1208 and 1209 are replaced by BAX12 types. Order number 5322 130 30424.

D. TRANSISTORS

Type	Ordering code	Item
BC107	4822 130 40357	TS38, TS42, TS238, TS242, TS406, TS407, TS408, TS409, TS411, TS412, TS501, TS504, TS606, TS607, TS808, TS811, TS901, TS902, TS1004, TS1006, TS1008, TS1106, TS1107, TS1406, TS1407, TS1408, TS1409, TS1411
BC109C	4822 130 40144	TS806, TS807, TS812
BCY70	5322 130 40324	TS506, TS809, TS911
BCY72	5322 130 40486	TS1001, TS1003
BDY38	4822 130 40524	TS1102
BDY60	4822 130 40852	TS1201, TS1202
BF179	5322 130 40661	TS916, TS917
BF338	5322 130 44108	TS916, TS917 (alternative type)
BFW44	5322 130 40672	TS914, TS918
BFY52	5322 130 40462	TS1103, TS1104
BFY90	5322 130 40493	TS28, TS29, TS36, TS37, TS39, TS41, TS228, TS229, TS236, TS237, TS239, TS241, TS703, TS801, TS802, TS803
BSX20	5322 130 40417	TS502, TS503, TS507, TS706, TS707, TS709, TS711, TS712, TS804, TS1002, TS1108
BSX21	4822 130 40321	TS1002
FW5324	5322 130 40142	TS31, TS32, TS33, TS34, TS231, TS232, TS233, TS234, TS413, TS414, TS416, TS417, TS601, TS602, TS603, TS604, TS608, TS702, TS903, TS904, TS906, TS907, TS908, TS909, TS912, TS913, TS1007.

E. SELECTED TRANSISTOR PAIRS

Type	Ordering code	Item
BFW11	5322 130 44031	TS26-1 & 2, TS226-1 & 2, TS704-1 & 2
BC107	5322 130 44029	TS401, TS402, TS1401, TS1402
BC109C	5322 130 40662	TS43-1 & 2, TS243-1 & 2
BFY90	5322 130 44035	TS403, TS404, TS1403, TS1404

F. MISCELLANEOUS PARTS

Item	Code number	Description
B1001	5322 131 20037	C.r.t. D14-120GH
B1002	5322 131 90021	Neon stabilizer ZA1004
B26	4822 134 20016	Neon stabilizer GL8
B226	4822 134 20016	Neon stabilizer GL8
LA1	5322 134 40054	Lamp 6828
LA2	5322 134 40054	Lamp 6828
LA3	5322 134 40212	Lamp 6226
VL1	4822 253 30021	Fuse, 1 A delayed action
	4822 253 30025	Fuse, 2 A delayed action
VL1101	4822 252 20001	Thermal fuse
L501	5322 158 10243	Coil 100 μH
L1001	5322 157 50708	Trace rotation coil
L1201	5322 158 20342	Coil
L1202	4822 157 50308	Coil
L1203	4822 157 50308	Coil
T401	5322 526 14001	Ferroxcube ring
T402	5322 526 14001	Ferroxcube ring
T501	5322 158 10361	Blocking transformer
T1001	5322 158 10359	Blanking transformer
T1101	5322 146 24024	Mains transformer unit
T1102	5322 158 14026	Suppression transformer
T1103	5322 158 14026	Suppression transformer
T1201	5322 142 60133	Converter transformer
T1401	5322 526 14001	Ferroxcube ring
T1402	5322 526 14001	Ferroxcube ring
RE601	5322 280 20042	Relay contacts
	5322 157 50093	Relay coil

G. LIMIT VALUES OF SELECT-IN-TEST COMPONENTS

Item	Power rating	Limit values
R108	0.1 W	39 Ω ... 82 Ω
R150	0.125 W	1 kΩ ... 5.6 kΩ
R308	0.1 W	39 Ω ... 82 Ω
R350	0.125 W	1 kΩ ... 5.6 kΩ
R1013	0.5 W	220 kΩ ... 1.2 MΩ
R1018	0.125 W	4.7 kΩ ... 47 kΩ
R1019	0.125 W	10 kΩ ... 39 kΩ
R1136	0.25 W	100 kΩ ... 330 kΩ
R1138	0.25 W	8.2 kΩ ... 15 kΩ

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industrial equipment division

72-09-30 PM 3210-03 Cd 758

TEST AND MEASURING INSTRUMENTS

Already published : Cd 725 and Cd 749

During manufacture of the 03-model of 25 MHz Dual-trace Oscilloscope PM 3210, the following modifications have been introduced.

IMPROVEMENT OF THE PROTECTION OF THE Z MOD INPUT

Transistor TS1004 : the former transistor BC107 has been replaced by a type 2N930, ordering code 5322 130 40051

Diode GR1004 : the anode of this BAX16 diode has been connected to the emitter of transistor TS1004. The cathode connection remains the same.

IMPROVEMENT OF THE LINEARITY

Carbon resistors R968 and R977 have been replaced by metal film resistors of 24,9 kΩ, ordering code 5322 116 54035.

PREVENTION OF OVERSHOOT ON SUPPLY VOLTAGES AT SWITCHING-IN AND OSCILLATIONS IN THE STABILIZED POWER SUPPLY

C1102 has been replaced by an electrolytic capacitor of 1 μF, 63 V, ordering code 4822 124 20569.
C1103 has been replaced by an electrolytic capacitor (minus pole to earth) of 1 μF, 63 V, ordering code 4822 124 20569.
R1118 has been replaced by a carbon resistor of 1 Ω, 1/8 W, ordering code 4822 110 60027.

MODIFICATIONS DUE TO STANDARDIZATION ETC.

C59, 62, 259, 262, 701, 833 and 836 have been replaced by electrolytic capacitors of 15 μF, 40 V, ordering code 4822 124 20359.
C502 and C503 have been replaced by miniature type ceramic capacitors of 22 pF, 100 V, 2 %, ordering code 5322 122 30022.
C504 and C505 have been replaced by miniature type ceramic capacitors of 33 pF, 100 V, 2 %, ordering code 4822 122 30016.
C813 and C814 have been replaced by electrolytic capacitors of 2,2 μF, 63 V, ordering code 4822 124 20571.
C1218 has been removed.

L1202 and L1203 have a new ordering code: 5322 157 54021.

R864 has been replaced by a metal film resistor of 33,6 kΩ, ordering code 5322 116 54322.

TS42, 242, 406, 407, 408, 409, 411, 412, 501, 504, 808, 811, 901, 902, 1106, 1107, 1406, 1407, 1408, 1409 and 1411 have been replaced by transistors of type BC407A, ordering code 5322 130 44148. TS43-1&2 and TS243-1&2 have been replaced by matched pairs of BC239C transistors, ordering code of a matched pair is 5322 130 44173.

GR916 and GR917 have been replaced by diodes of type BZX61/C62, ordering code 5322 130 30669.

ERRATUM IN MANUAL PM 3210

In chapter XII. LIST OF MECHANICAL PARTS, the code numbers of the contrast filters have been interchanged.

Correct is: 5322 450 60091 Contrast filter green
5322 450 60092 Contrast filter grey.

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19-6-1972 SERVICE INFORMATION Cd 749

TEST AND MEASURING INSTRUMENTS

Re: Cathode-ray tube for oscilloscope PM 3210/01/02/03

The cathode-ray tubes D14-122GH, D14-122GM and D14-122GP exist in two models. One is provided with an aquadag coating, the other one not. The c.r.t. with the aquadag coating have shortly been given an extended type number, viz. D14-122GH/A, D14-122GM/A and D14-122GP/A.

As it is essential to use a c.r.t. with aquadag coating for the PM 3210 oscilloscope, you must make sure that you order a D14-122GH/A, D14-122GM/A or D14-122GP/A type when you need a replacement tube.

When you order tubes at the Concern Service Dept. under code number 5322 131 20037 as mentioned in the manual of the PM 3210 oscilloscope, you will automatically receive the right tube D14-122GH/A.

N.B. In the PM 3210 manual type number D14-120GH is stated for the c.r.t. However, the Concern Service supplies under code number 5322 131 20037 a D14-122GH/A tube which is the same tube, but provided with the trace rotation coil.